Kelsey Creek Watershed Assessment

A Document of the Big Valley Watershed Council

Prepared for:

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1.0 Background

The purpose of the Kelsey Creek Watershed Assessment is to collect and integrate information on past and present watershed conditions and management. The assessment is intended as a tool to educate landowners on watershed conditions and management needs. As the first effort to compile available information on the watershed, the assessment helps identify data gaps and future needs for information to understand watershed processes. It also provides a basis for watershed planning and identification of necessary watershed restoration and management projects.

1.1 History of the Big Valley Watershed Council

The Kelsey Creek Watershed Assessment is a document of the Big Valley Watershed Council. Kelsey Creek is the largest creek entering Big Valley. Other large creeks include Cole Creek, Adobe Creek, and Highland Springs Creek.

In early 2001, several community members requested assistance from the East Lake and West Lake Resource Conservation Districts (RCDs) on the formation of a watershed group for the Big Valley area. The RCD Directors agreed to help their constituents and held a series of meetings and tours in the watershed. The RCD's Watershed Coordinator and U.C. Cooperative Extension's Forest Advisor gave a presentation before an audience of approximately 60 stakeholders explaining the Coordinated Resource Management and Planning (CRMP) process and the value of working together as a planning/watershed group. From the initial meeting, a watershed tour was arranged for the group by the RCDs and Lake County Public Works Department (LCPWD). Thirty-five people joined the tour to visit ten sites in the Big Valley area, encompassing Adobe Creek, Cole Creek, and Kelsey Creek. Attendees learned of many issues in the Big Valley area including: erosion, flooding, sedimentation, fuel loading, illegal dumping, and non-native invasive weeds.

On May 22, 2001, landowners and stakeholders signed a Memorandum of Understanding to form the Big Valley CRMP, later to become the Big Valley Watershed Council. The group created a mission statement, identified and prioritized their issues and concerns, and sought aid in creating projects. The first item that was addressed was illegal dumping along the streambanks of Kelsey Creek. The group organized their first annual cleanup in 2001, with the assistance of West Lake RCD (WLRCD) and LCPWD.

The second item the group addressed was the need for a watershed assessment (inventory of current conditions) to document issues in the watershed. On February 4, 2002, WLRCD presented the local Lakeport Partnership Office of the Natural Resources Conservation Service (NRCS) with a formal request to help the group conduct an assessment. The Area Conservationist assigned the (then) State Office "Stream Team" to work with the group to develop an assessment.

A series of meetings and tours were held with Stream Team members gathering information and assembling data and photographs in the watershed. One of the most prominent issues brought to light was the fuel loading of the upper watershed. A catastrophic wildfire would have devastating effects on the lower watershed and Clear Lake. Group members divided the watershed into four sections and each group gathered additional information and documented their information into different formats, resulting in the need to assemble the data into a usable document/report.

In 2006, the West Lake RCD Watershed Coordinator was successful in obtaining a CALFED Watershed Subcommittee Prop 50 grant, administered by the State of California Department of Water Resources, to complete this assessment. As a result of these activities, this Kelsey Creek Watershed Assessment has been created.

Figure 1.1. Aquatic education on Kelsey Creek.
Photo by Greg Dills.

Kelsey Creek is the third largest tributary to Clear Lake, and during the evolution of the watershed group, the State of California, State Water

Resources Control Board, adopted two Total Maximum Daily Load (TMDL) requirements for Clear Lake identifying mercury and nutrients as pollutants. The Kelsey Creek Watershed Assessment will become part of the county's planning document to comply with the TMDL requirements.

The Big Valley Watershed Council updated their mission statement in 2007 to the following:

> "We are citizens, who reside in the watershed, own property here, or otherwise have an interest in its well-being. Our purpose is to protect, enhance, and improve the surface and groundwater resources, stabilize historic channel elevations, and enhance the natural systems of the Kelsey Creek Watershed. Our goal is to provide cooperative management and protection. To this end, we will evaluate and recommend solutions to watershed problems that benefit both the users and the watershed."

1.2 Watershed Assessment Process

Following the California Watershed Assessment Manual approach for watershed assessments, the Big Valley Watershed Group held stakeholder meetings to identify issues of concern in the Kelsey Creek Watershed. While the scope of the assessment goes beyond these issues, this process helped to ensure that priorities of watershed stakeholders were addressed. The issues identified were:

- Protecting water quality.
- Ensuring water availability.
- Fire hazard management.
- Reducing illegal dumping.
- Flood management and debris jams.
- Improvement of lower Kelsey Creek channel conditions.
- Restoration of native fish populations.

This document begins with sections describing watershed resources and processes (Sections 2-15). The agencies and organizations involved in watershed management are covered in Section 16. Section 17 summarizes findings related to the watershed issues identified by the Big Valley Watershed Council and identifies information gaps found during the assessment process.

2.0 Watershed Description

The Kelsey Creek Watershed is located in the Northern California Coast Ranges about 80 miles north of San Francisco. The watershed lies almost entirely within the boundaries of Lake County, and immediately to the south lies Sonoma County (Plate 1). The Kelsey Creek Watershed ranges from the summit of Cobb Mountain covered with pine and fir forests at 4,722 feet elevation, to the level farm lands of Big Valley along the shore of Clear Lake, 1,318 feet elevation (Plate 2).

Kelsey Creek is the third largest tributary to Clear Lake, entering the lake along the southern side of the Upper Arm (Plate 3). Kelsey Creek contributes approximately 16% of the streamflow into Clear Lake. With an area of 28,614 acres, or 44.7 square miles, the Kelsey Creek Watershed occupies about 10% of the entire Clear Lake Watershed (Richerson *et al*. 1994). Because the Kelsey Creek Watershed boundary occupies a narrow corridor through Big Valley, for purposes of this assessment, an expanded area of interest between Cole Creek and McGaugh Slough in Big Valley is included, giving a total area of 34,692 acres (Figure 1.2). Clear Lake is unusual for its size, abundant fisheries and wildlife, and age. Not only is Clear Lake the largest natural lake located entirely in California, it has apparently existed as a shallow lake for at least 480,000 years without filling in. Due to local faulting, the lake basin has shifted downward at approximately the same rate that sediment fills it. Clear Lake is not especially clear as its name implies, but has been a eutrophic, or algae and plant rich lake, for most of its history (Sims *et al.* 1988). This abundant growth in turn feeds large fish and wildlife populations. Clear Lake drains to the east via Cache Creek into the Sacramento River.

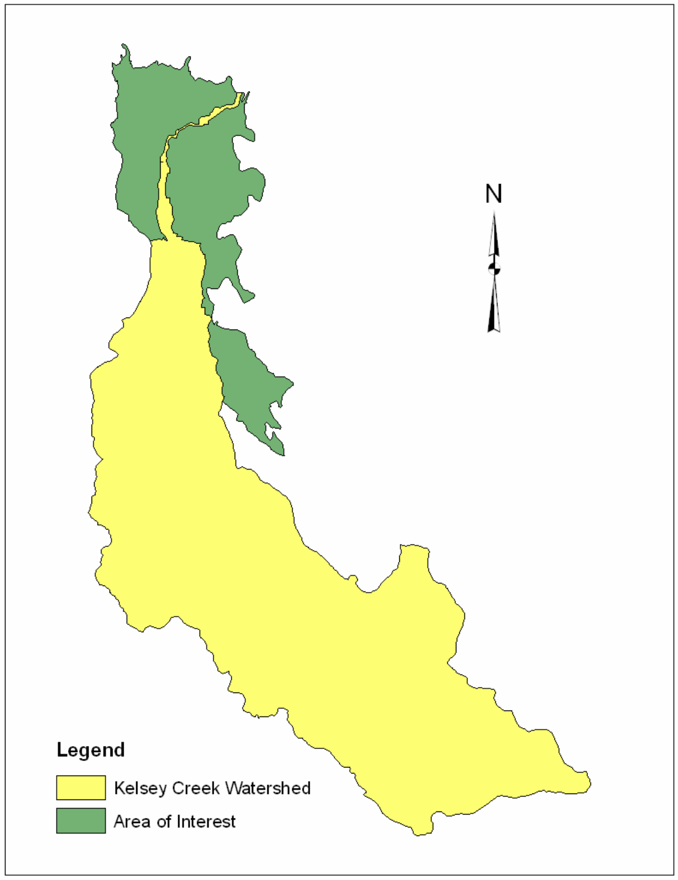


Figure 1.2 Kelsey Creek Watershed boundary and additional area of interest.

At the lower end of the Kelsey Creek Watershed, wetlands are found along the shores of Clear Lake, and remnants of valley oak woodlands that may once have covered most of Big Valley are found along watercourses and near the shores of the lake. Most of Big Valley has been converted to agricultural and urban uses. Deep alluvial soils support pears, wine grapes, hay, and pasture land. The town of Kelseyville, the largest community in the watershed, is located on the eastern side of Big Valley.

As the land rises to the south of Big Valley, blue oak woodlands, grey pines, and annual grasslands predominate. By approximately 2,000 feet elevation, chaparral becomes the dominant vegetation. Scattered areas of coastal oak woodlands occur along higher ridges. At the upper end of the watershed, in soils formed on volcanic materials, conifer forests and mixed hardwood-conifer forests are found. Resort and residential communities in the Cobb area are set in these forested surroundings.

Figure 2.1. Big Valley Watershed Council members Robert Stark and Bill Stockton tour Kelsey Creek in a meadow near Bottle Rock Rd. Cobb Mountain in background. *Photo by Kevin Ingram.*

3.0 Watershed History

At the time of European contact, Native Americans had been living in the vicinity of Clear Lake for at least 10,000 years, and they lived in balance with their environment. The arrival of Europeans was devastating for native peoples who were decimated by new diseases, forcibly relocated and forced to work for Europeans, and severely punished or killed for lack of cooperation. The history of interactions among Native Americans, the Spanish, Mexicans, U.S. citizens, and other European settlers is long and complex and is beyond the scope of this assessment. This section will focus on ways in which people made use of watershed resources and the changes that occurred due to human activities.

Nevertheless, because a deplorable incident involving American settlers and United States government actions toward Native Americans began in the Kelsey Creek Watershed, it is mentioned here, and a longer account is included in Appendix A. Brothers Andrew and Benjamin Kelsey and Charles Stone were living across from the current site of the town of Kelseyville and raising horses and cattle with the help of local Native Americans. "These Americans…adopted the most brutal and repressive measures, starving, beating and murdering their Indian workmen" (Cook, 1943, quoted Dillon, B.D. 1995). In 1849, at a time when Benjamin Kelsey was away, the Native Americans killed the two other Americans. This led to an expedition by U.S. Army forces and the massacre of a large group of Indians on what is now called Bloody Island near the town of Upper Lake. This group probably had nothing to do with the Stone and Kelsey murders (Dillon, B.D., 1995).

At the time of European contact, the Kelsey Creek Watershed was unusual because there were as many as five different Native American groups in the area (Dillon, B.D. 1995, McLendon, S. and M.J. Lowy 1978). The Eastern Pomo lived around the northern and western sides of Clear Lake in several communities. Two villages, one called *Kulanapo* in Big Valley near the current location of Lakeport, and one called *Habenapo* near the current location of Kelseyville, had territories from the lakeshore southward into the foothills and mountains, and according to Dillon (1995) "it is probable that the entire Kelsey Creek drainage was considered to be *Habenapo* territory."

The Wappo inhabited a territory south of Cobb Mountain that included the present location of Middletown and much of the Napa Valley. The Northern Wappo, from the area around Middletown, also had a presence along the shore of Clear Lake to the north and west of Mt. Konocti, probably at least partly within the Kelsey Creek Watershed. Here they had "access to two of the richest resources in Northern California; the Clear Lake fishing and waterfowl hunting grounds, and the Konocti obsidian" (Dillon, B.D. 1995). There is some dispute as to whether the Wappo were permanent or seasonal residents in the area. It is probable; however, that Indian foot trails across what is now Boggs Mountain Demonstration State Forest were used by the Wappo.

Other tribes with nearby territories who possibly used the Kelsey Creek Watershed include the Southeastern Pomo, whose permanent settlements were on islands in the Oaks and Lower arms of Clear Lake, the Lake Miwok, whose territory extended to the southernmost point of Clear Lake, and the Patwin, whose territory may have been within a few miles of the upper Kelsey Creek Watershed (Dillon, B.D. 1995).

McLendon and Lowy's description of the way of life for the Eastern and Southeastern Pomo around Clear Lake gives an idea of Native American resource use. Both groups used tules, rushes growing around the lake, to build boats and houses and make clothing. While fish from the lake were available year round, fishing activities were concentrated on the spring spawning season when vast numbers of fish filled the creeks surrounding the lake. Fish were dried and stored to be eaten for the rest of the year and were traded with other Native American groups. Other foods that were stored and eaten year round included acorns to be made into bread and mush, grains, pepperwood nuts, and buckeyes. When available, fresh meat, water fowl, fresh greens, roots, bulbs, berries, and fruits were also consumed (McLendon, S. and M.J. Lowy 1978).

As described for the Pomo above, Native Americans made extensive use of natural resources without apparently over-using these resources. One way they may have actively modified their environment, however, was through the use of fire. Although one study of the Clear Lake area found that "Indian burning in the Clear Lake area was on such a limited scale that it had little effect on the vegetation cover" (Simoons, F.J. 1952), a compilation of references on the use of fire by Native Americans lists references for all of the tribes mentioned above (Williams, G.W. 2003). The compilation gave a variety of reasons for which Native Americans used fire. These include clearing ground for acorn harvest, travel, or hunting, and increasing food availability for prey animals. Of course, accidental fire starts would have occurred as well.

On a broad level, the Kelsey Creek Watershed at the time of European contact looked as it does today. Some of the earliest written descriptions of the vegetation in the Kelsey Creek Watershed describe conifer and mixed hardwood-conifer forests at higher elevations, chaparral (brush) on hillsides at middle elevations, and grasslands interspersed with oak trees in large, level valleys (Simoons 1952).

> ***At the top of the watershed:*** An 1890 description of timber resources on Cobb Mountain described them as "chiefly Pinus ponderosa but there are some firs and oaks, and some sugar pine" (CSMB 1890, quoted Simoons 1949).
>
> ***At middle elevations:*** Vegetation on the Mayacmas Range to the south of Big Valley was described in 1851, "the crest of the mountains being covered only with chamise, dwarf-oak and mansanita bushes" (Gibbs 1851 quoted Simoons 1949).
>
> ***And in Big Valley:*** In 1851 Big Valley was described as "covered with abundant grass, and interspersed with groves of superb oaks of the most varied and graceful forms, with the lake and its green margin of tule in front" (Gibbs 1851 quoted Simoons 1949).

Of these three landscapes, Big Valley has changed the most with almost all of the level ground converted to agricultural use, most of the oak trees cleared, and wetlands filled in or tules removed along portions of the lakefront.

Although the broad landscape picture remains today, changes in watershed conditions began soon after the arrival of Europeans. Starting in the 1830s hunters and trappers came to Lake County. In 1839 Salvador Vallejo and his brother Juan Antonio began grazing cattle throughout a large land grant covering the areas of Upper Lake, Bachelor, Scotts, and Big Valleys. Settlement by American agriculturists began soon after California gained statehood in 1850, and there were about 1,000 Americans in the area of Lake County by the time of the 1860 census. Farmers made up the majority of the population, and they cleared land, primarily in the valleys, to plant crops such as grains, potatoes, grapes, and orchard crops. Lake County's geographic isolation precluded large scale commercial production of these crops because transportation to market was too difficult. Cattle and sheep production became the major source of income during the twenty years after agricultural settlement because the animals could be driven over the mountains to markets (Simoons, F.J. 1952).

Livestock grazing and other activities dramatically changed the grasses found in grasslands and oak woodlands.

> "The interior grassland was probably dominated by half a dozen species of bunchgrasses, particularly purple and nodding needlegrasses (sp. *Nasella*), fescue (*Festuca californica*), ryegrass (*Elymus glaucus*), squirrel tail (*Sitanion hystrix*) and two species of melic grass (sp. *Melica*)…The grazing pressure and soil-surface disturbance favored exotic annuals over the native bunchgrasses. In addition, fire was controlled and weed seeds were accidentally introduced. In a dramatically short time, bunchgrass prairie was converted to an annual grassland of European grasses and forbs" (Barbour, M.G. and Whitworth, V. 2001).

The use of fire by settlers was probably common prior to the early 1900s. Cattlemen and sheep herders burned brush lands to increase forage for livestock, and hunters and campers frequently set fires (Simoons, F.J. 1952).

Timber production for local use began in 1856 when John Cobb opened the first sawmill along Kelsey Creek in Cobb Valley. Mining for borax at Borax Lake, north of the present day City of Clearlake, and for sulfur and mercury at the Sulphur Bank Mine on the Oaks arm, increased demand for lumber, both as fuel wood for reducing furnaces and timber for underground supports. Oak was the major source of fuel wood. However, most of the timber came from the forests in the volcanic uplands of Kelsey Creek and adjacent watersheds (Simoons, F.J. 1952).

A history of timber production in the area of Boggs Mountain State Demonstration Forest (BMSDF) is given by Dillon (1995), however specific information on timber production in other areas of the Kelsey Creek Watershed was not found for this assessment. By the turn of the century, most of the best timber had been cut in the area of BMSDF, and the land was being used more for livestock grazing than timber production. Following World War II, with a tremendous demand for lumber for new construction, remaining and re-grown timber in the entire area of BMSDF was cut over. The state purchased the land for the state forest for the low price of $38,700 in 1949 "because it was adjudged that just about every stick of merchantable timber over the bulk of the property had been cut; from the beginning an important research concern at Boggs Mountain Demonstration State Forest was the study of forest recovery from a completely cutover area" (Dillon, B.D. 1995). No commercial cutting was done on the forest for the next 17 years, after which small timber harvests were initiated and continue in order to offset operating costs of the forest and further the research and teaching component of the State Forest system. Today BMDSF is a young and even-aged forest with predominantly 50 year old trees, however forest management objectives are to “create an all-aged forest structure, with stands containing a variety of age and size classes” that “will provide for a more biologically diverse habitat than is found in the current predominantly young forest” (CDFFP 2008).

Mineral spring resorts in Lake County became popular vacation spots for visitors from the Central Valley and San Francisco Bay Area starting in the 1850s. Immediately to the east of the upper portion of the Kelsey Creek Watershed were several popular hot springs resorts. The Glenbrook Resort, located near the intersection of Kelsey Creek and Bottlerock Rd., was a stage stop between the Bay Area and resorts to the south, and the lake and resorts to the north. In the 1910s and 1920s, road improvements led to a string of new resorts along the roadways (Simoons, F.J. 1952).

Beginning in the 1920s prospecting for geothermal energy resources began in and to the south of the Kelsey Creek Watershed. The area from the upper Kelsey Creek Watershed, and continuing south in Lake and Sonoma Counties, is an important area for geothermal resources. The first commercially successful geothermal plant in the area was developed in 1956, and many more have been developed to the south of the Kelsey Creek Watershed since (Dillon, B.D. 1995). There are currently approximately 60 active geothermal wells located within the Kelsey Creek Watershed.

Better transportation routes also led to the success of several agricultural crops in Lake County. The acreage of walnuts and pears both began to increase starting in the 1900s. With only one period of decrease in the 1940s, crop area countywide increased to almost 10,000 acres of walnuts and 8,000 acres of pears by 1980. A significant proportion of the walnut acreage was in unirrigated orchards on hillsides. Pears were found on level valley ground, and while initially many were unirrigated, there was a transition to irrigation because it led to substantially higher yields. Since 1980, there has been a large decline in the acreage of pears and walnuts to about 2,500, and 2,800 acres respectively by 2005.

Although the first vineyards in Lake County were planted in the 1870s, there were only 600 acres of grapes in 1910 and this dropped to 260 acres by 1970. Beginning in the 1980s; however, winegrape acreage began to increase, reaching 8,500 acres in 2005 (County of Lake Department of Agriculture, various). In the Kelsey Creek Watershed, most of the acreage of grapes, walnuts, and pears as well as hay and other minor crops is found in the level portion of Big Valley (DWR 2001 land cover data). Water use by agriculture is discussed in the water availability section below.

Figure 3.1. Pear orchard at Quercus Ranch, near the mouth of Kelsey Creek, circa 1910. *Photo courtesy of Lake County Museum.*

While many land use activities have the potential to increase soil erosion, it appears that the development of heavy earth-moving equipment made the greatest difference in erosion from the watershed. Researchers found a 10-fold increase in sedimentation rate to Clear Lake from the time period before to the time period after 1927, which they attributed to the advent of heavy earth-moving equipment.

> "As Simoons (1952) noted, the woody vegetation of the upland areas of the Clear Lake basin were not appreciably altered by early settlers, whose land clearance was focused on level ground with low erosion risk. Our cores tentatively suggest that grazing, wood cutting and lumbering, agricultural clearing, and the development of small towns and recreation facilities, as conducted from 1854-1927, were relatively low-impact activities from a watershed mass-balance perspective. It is encouraging to think that one of California's rugged, semi-arid environments apparently supported a fairly large, active human population in a reasonably sustainable fashion. A narrow range of activities—open pit mining and large scale earthmoving—would appear to have been responsible for the stresses most obvious in our cores (Richerson *et al.* 2008)."

Gravel for use inside Lake County for construction and road building was taken primarily from stream systems prior to about 1985 (LCPD 1992).

Gravel mining and many other activities directly altering stream channels are described in the stream channels section below.

4.0 Geology

The California Coast Ranges were created when ocean and continental plates collided and "sediments, submarine volcanoes, and oceanic crust were scraped from the down-going plate and attached to the North American plate" (Moores and Moores 2001). This process of subduction created the Franciscan Complex, the mixture of rocks comprising much of the California Coast Ranges. Movement of tectonic plates on the California coast later produced a series of faults paralleling the San Andreas fault. These faults create the north/northwest-south/southeast valleys and ranges seen in the Coast Ranges (Christensen Associates Inc. 2006).

The Clear Lake Basin was created by the interaction of faults in the San Andreas system. The area underlying the main portion of the Clear Lake Basin began to subside about 600,000 years ago in association with the eruption of a portion of the Clear Lake volcanic field (Hearn, B.C. and R.J. McLaughlin 1988). The lake has remained shallow with the rate of downward vertical movement of the basin roughly equal to the rate of sedimentation (Richerson *et al*. 1994).

The Clear Lake Volcanics are located around the eastern end of Clear Lake and continuing southward. They are the northernmost volcanic field in a series found throughout the California Coast Ranges. Within the Clear Lake Volcanic field, eruptions began ±2.1 million years ago and migrated northward (Donnelly-Nolan 1990). Cinder cones and maars around the lake are evidence of the most recent eruptions, which occurred about 10,000 years ago (Smithsonian Institution 2004).

Franciscan Complex rocks are found in the middle portion of the Kelsey Creek Watershed and include sandstone, greenstone, and serpentinite (Plate 4). Sandstone is a sedimentary rock formed from cemented sand. Greenstone, found along the southwestern side of the Kelsey Creek Watershed, is metamorphosed volcanic rock (basalt) from ocean plates. Serpentinite is a rock formed of serpentine group minerals. Serpentine minerals are formed by alteration of ultramafic rocks, which are high in magnesium and iron and low in silica. The Clear Lake volcanic rocks occur along the southern and eastern sides of the watershed as andesite. The lowest (northern) portion of the watershed consists of alluvium, material deposited by running water.

Christensen Associates Inc. (2003) gave a detailed description of changes in landforms of Big Valley and the uplands to the south. It is summarized here and included in Appendix B. The Kelseyville Formation was formed largely from lacustrine (lake) sediments deposited beginning with the formation of Clear Lake 600,000 years ago. Included in the formation is a layer of tuff rock formed from consolidated volcanic ash that was ejected during an eruption. This layer is an important aquifer in the Big Valley uplands. About 300,000 years ago, the southern half of Big Valley was uplifted approximately 400 feet due to the interaction of local faults. This created the uplands in the southern end of Big Valley. Several creeks combined to erode what is now Adobe Creek valley and to deposit a delta at the south margin of Clear Lake. This produced a valley at an elevation of about 1,280 feet which was eventually filled in to Big Valley's present elevation of about 1,380 feet by alluvial deposition. The Christensen Associates report gives further details of probable shifts in the courses of Adobe, Highland Springs, Kelsey, and Cole Creeks during the period of deposition that explain the location of the aquifers described in the hydrology section below.

5.0 Soils

Major factors influencing the types of soils in the Kelsey Creek Watershed include the type of rock or unconsolidated material on which they formed, and the topography of the area where they formed. As a general rule, soils are shallower as slopes become steeper due to naturally higher rates of erosion. They are deepest in valley locations where materials accumulate.

On the nearly level plains of Big Valley and in smaller mountain valleys, soils formed on alluvial and lacustrine materials (Plate 5). Alluvial material, or alluvium, is sediment and gravel transported by streams and rivers. Lacustrine material consists of sediments that accumulated in a lake. In the past, the level area of Big Valley was part of Clear Lake, and much of it is underlain by lacustrine deposits. In places the deposits are found at the surface, especially near the edge of the lake.

Alluvial soils are generally deep. Frequently, they have layers with different fine particle sizes (sand, silt, and clay) and varying gravel content, and these layers affect the ability of water to drain through the soils. In alluvial soils, the chemical composition, and therefore the inherent fertility and ability to support native vegetation or crops, depends on the source material of the alluvium. In Big Valley, the alluvium is a mixture from the source rocks higher in the watershed. In general, Big Valley's alluvial soils make excellent agricultural soils, although some are limited by drainage characteristics or fertility.

Lacustrine soils in Big Valley include poorly drained marsh soils where the water table varies from 1 foot above to 3 feet below the surface. Further away from the lakeshore, lacustrine soils are poorly drained, dark, expansive clays with construction and cropping limitations due to their high shrink swell potential (USDASCS 1989).

In mid elevations of the Kelsey Creek Watershed, soils formed on sedimentary and ultramafic rocks. Sedimentary rock types in the Kelsey Creek Watershed are commonly sandstone, but also include siltstone and shale, made from cemented silt and clay, respectively. These rocks tend to weather to soils with particle sizes similar to those of the source rock. Ultramafic rocks (commonly referred to as serpentine) are infertile and sometimes contain elements that are toxic to most plants. They are high in magnesium and iron, and may be high in heavy metals such as nickel, chromium, and cobalt. They have low silicon content and generally have low calcium, potassium, and phosphorus. Only specially adapted plants can survive on some soils formed in ultramafic rocks, and vegetation is generally sparse on these soils.

Soils formed on volcanic rocks occur in the highest reaches of the watershed on Cobb Mountain and at Boggs Mountain Demonstration State Forest and in the middle watershed where newer volcanic deposits from the Clear Lake volcanic system occur. Soils formed on volcanic rock are generally fertile, supporting conifer and hardwood forests at the top of the watershed.

In most of the middle and upper watershed, soils are well drained due to their position on sloping ground, which permits water to drain away.

Names and characteristics of soils comprising more than 200 acres of area in the Lake County Soil Survey are listed in Appendix C.

6.0 Hydrology

6.1 Physical Conditions

Starting at an elevation of 3,840 feet and dropping to 1,318 feet at Clear Lake, Kelsey Creek is approximately 22.5 miles in length (Plate 3). In its upper reaches, Kelsey Creek and several of its tributaries, Lee, Jones, and Alder Creeks, flow year round. The lowest portion of Kelsey Creek usually goes dry in mid-summer from the Main Street Bridge in Kelseyville to the mouth of the creek at Clear Lake (DFG 1970a, DFG 1974a). The stream is moderately steep in the upper reaches and can be quite steep through the canyons before reaching the nearly level plains opening to Big Valley.

6.2 Diversions and Barriers

DFG stream surveys make note of two falls that form complete barriers to fish passage on Kelsey Creek. The locations and descriptions of the size of the falls vary somewhat among the surveys. The upper falls occur approximately 3.5 miles below Glenbrook and are a series of two or three approximately 15 foot falls. The lower falls are about 3.3 miles above the mouth of Sweetwater Creek, and these falls are about 20 feet in height (DFG 1958, 1970a, 1974a). Two DFG surveys note numerous pipe diversions and some summer diversion dams, especially in lower Kelsey Creek. Given the time that has elapsed since the DFG surveys, it is likely that these diversions have changed by the present time.

Three significant man-made barriers occur in lower Kelsey Creek, and one has recently been removed (Plate 3):

1. The old Quercus Bridge, approximately 1,100 feet south of Soda Bay Road, consists of the old bridge abutments with large sections of fallen concrete from the bridge forming a barrier across the creek.

2. About one mile upstream, the Kelsey Creek Detention Structure was completed in 1987 (Figure 6.1). It was constructed to increase groundwater recharge and raise the streambed level upstream of the structure. When control gates are open, it forms a dam across the creek approximately 2 feet high. When control gates are closed, it forms a dam approximately 10 feet high. There are two permanent rock and concrete fish ladders on either side of the structure that allow fish passage over the 2 foot dam.

3. To prevent stream down-cutting from damaging the Main Street Bridge in Kelseyville, a footing was built across the downstream side (Figure 6.2). This footing creates an approximately 4 foot high dam across Kelsey Creek. There is a fish ladder at this site, but Clear Lake hitch, a California Species of Special Concern, have not been able to use it successfully.

4. Below the Main Street Bridge, the Merritt Road low water crossing created a barrier to fish passage; however, it was replaced with a bridge allowing fish passage in 2007.

Figure 6.1 Kelsey Creek Detention Structure with the gates up. Fish ladders on either side of the structure culminate in a narrow notch (foreground of picture) which provides limited, but not complete, passage for Clear Lake hitch. *Photo by Greg Dills.*

Figure 6.2 Footing below Main St. Bridge in Kelseyville. Fish ladder, seen on far side of picture, is not used by Clear Lake hitch. *Photo by Greg Dills.*

A dam and reservoir for flood control and augmentation of water supplies was proposed for Kelsey Creek approximately 5 miles south of Kelseyville. Lake

County paid for several geologic and economic feasibility studies from 1964 to 1981 until the eventual abandonment of the project (SMFE 1964, Tudor Engineering Co. 1973 and 1982). In 1981 it was determined that without the reactivation of interest-free loan programs from the federal government, the cost of irrigation water from the project would be prohibitive.

6.3 Climate

California's North Coast has a Mediterranean climate with moderate, wet winters and warm to hot, dry summers. Long term weather records for the Kelsey Creek Watershed are not available, so weather records for Lakeport, approximately five miles west of the mouth of Kelsey Creek at Clear Lake, are shown in Figure 6.3. Local topography influences weather patterns, and rainfall generally increases with higher elevation, ranging from 24 inches per year at the bottom of the watershed to over 50 inches per year at the top (Plate 6). At lower elevations in the Kelsey Creek Watershed, snow fall is rare, and almost all precipitation occurs as rain. At higher elevations, snow fall occurs in most years; however, amounts rarely exceed a few inches in depth[1] (WRCC 2008). Therefore, snow storage has minimal impact on the watershed's hydrology.

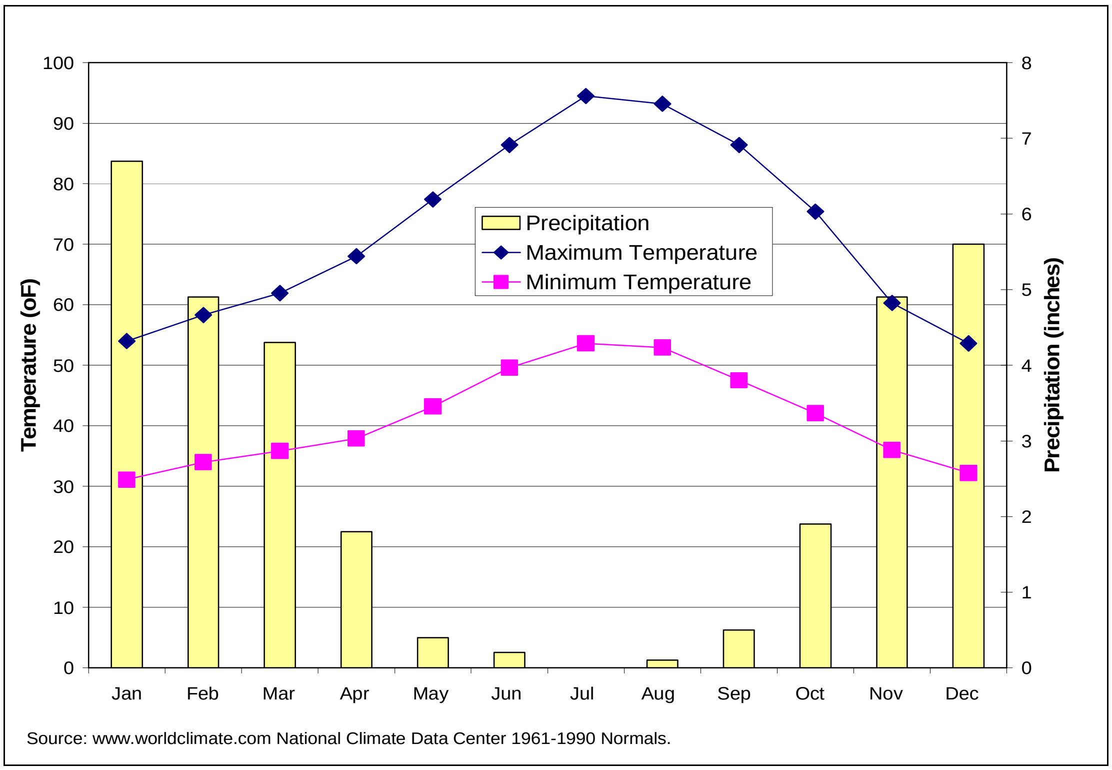


Figure 6.3 Average monthly temperature and rainfall for Lakeport, California, near the lower Kelsey Creek Watershed.

[1] No snow depth data were found for the upper Kelsey Creek Watershed. Information referenced here is for Hobergs, elevation 3,015', located just outside the watershed boundary to the north of Boggs Mountain Demonstration State Forest.

6.4 Streamflow

There are two stream gages on Kelsey Creek, one near the mouth at Clear Lake and the other approximately nine miles upstream (Plate 3). The average annual flow for each gage is reported in Table 6.1. Average annual flow encompasses dry periods and all flow rates over the entire year.

Over the periods of record, there was less flow at the upstream gage. However, when the average annual flow at the gages was compared for the concurrent years of record, it was very similar, 84.5 cfs near the mouth of Clear Lake and 85.7 cfs upstream. Because the upstream location gages a smaller portion of the watershed, it might be expected that it would carry less streamflow than the downstream location. However, water can be lost from a section of stream through evaporation and outflow to groundwater. The section of Kelsey Creek between the two gages is important for groundwater recharge of Big Valley aquifers (SMFE 1967, Christensen Associates Inc., 2003).

Table 6.1. Summary of stream gage data.

Operating Agency & Station No.	Location	Average Annual Flow (cfs*)	Period of Record (years)	Gage Area (miles^2)
USGS 11449500	Approximately 4 miles upstream of Highway 29	73.9	1947-2007**	36.6
DWR A85005	Near the mouth at Clear Lake	81.9	1982-2005***	43.7

*cfs = cubic feet per second.
**No data for 2001.
***Data for 1990, 1991, 1996, 2000, 2002 not used due to significant data gaps.

In Figure 6.4 annual average flows are shown by water year[2]. These flows vary greatly depending on annual precipitation. During the period of record, they ranged from 4.8 cfs in 1977 to 206 cfs in 1983.

The peak streamflows for each water year are shown in Figure 6.5. These are instantaneous flows (measured every 15 minutes), rather than the average flow for the entire year, so they are much higher flows. Statistical analysis of these peak flows is used to estimate the size of floods expected to occur at a 100 year or other frequency. In Figure 6.5 the 1.5 and 100 year peak flows are shown. The 1.5 year recurrence interval corresponds approximately to the bankfull stage of streamflow, or the flow at which the stream is flowing to the top of its banks (Figure 6.6). This flow level is most important in forming the stream channel (Leopold, L.B. 1994). The 100 year peak flow corresponds to what is termed the 1% annual chance flood or the 100 year flood.

[2] The water year goes from October 1 to September 30 and is designated by the year in which it ends. Annual average flow is the flow rate averaged over one year. Average annual flow (in Table 6.1) is the long term (many year) average of annual average flows.

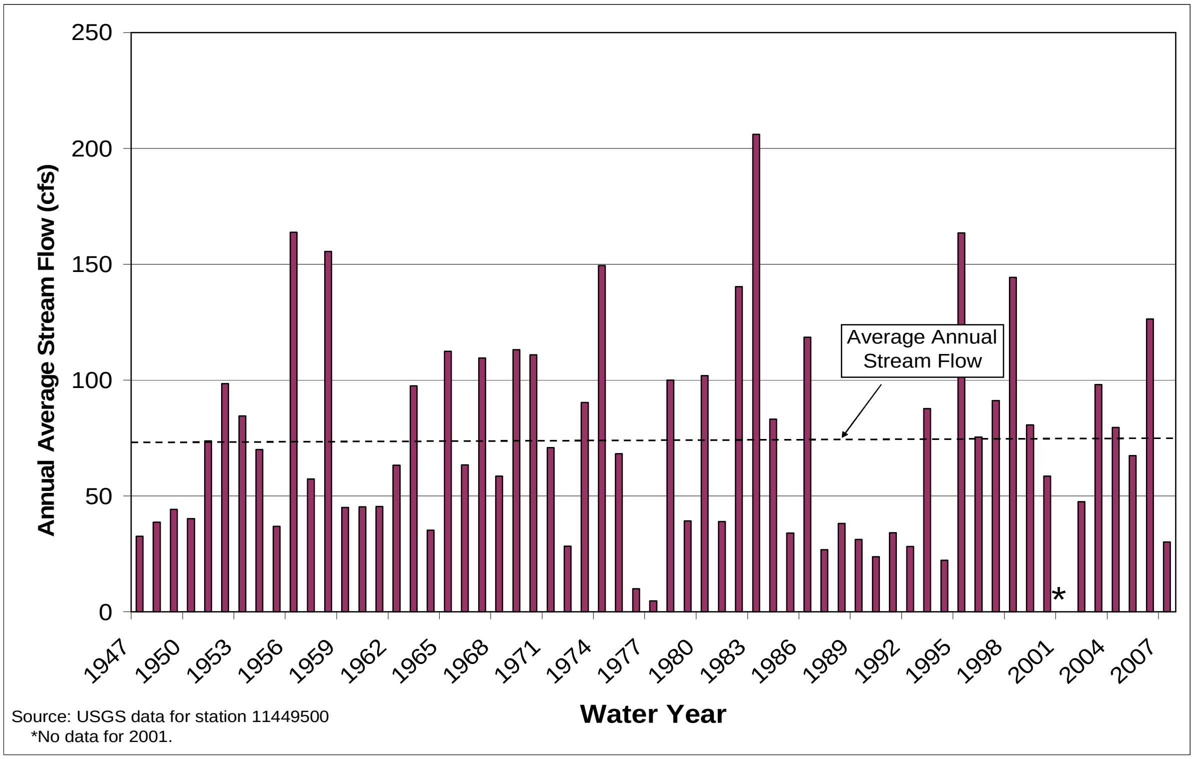


Figure 6.4 Annual average streamflows in Kelsey Creek at the USGS gauging station.

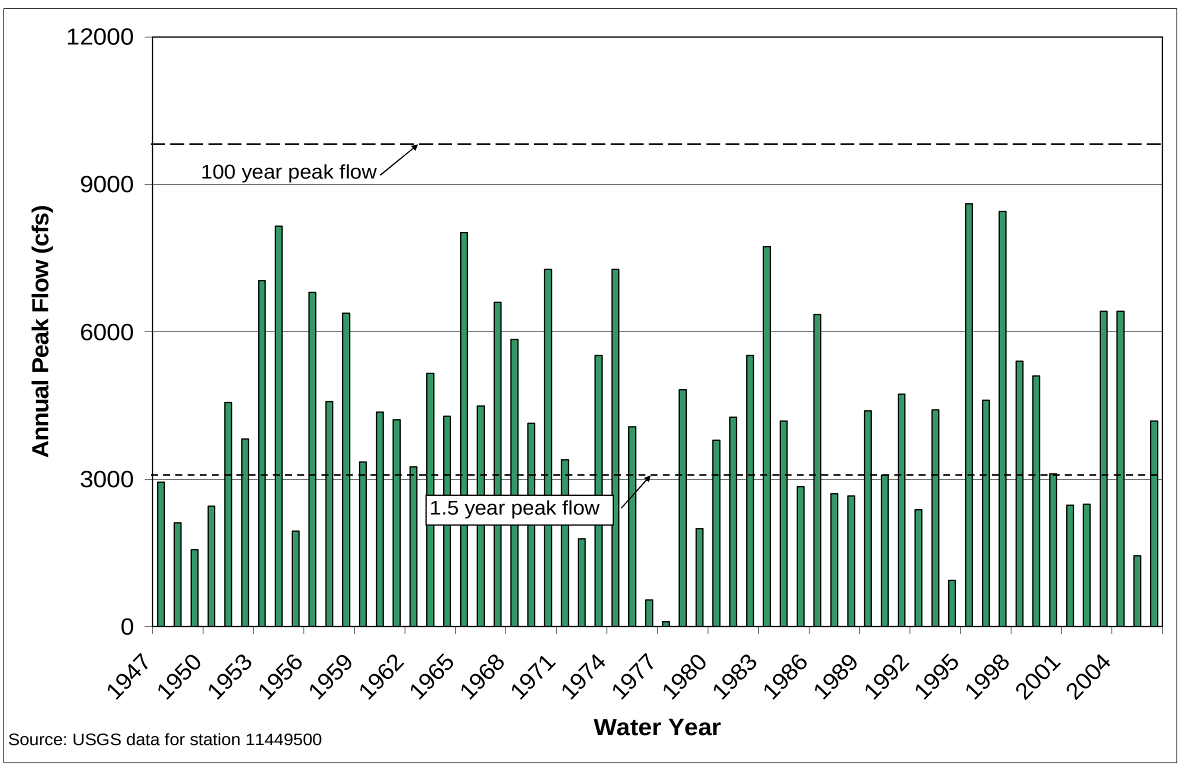


Figure 6.5 Annual peak flows in Kelsey Creek at the USGS gauging station.

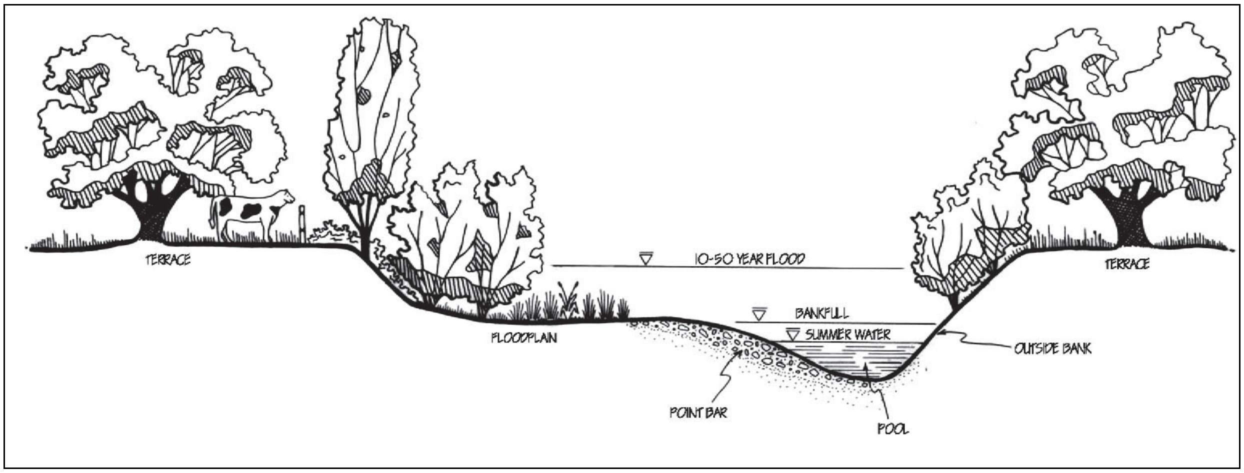


Figure 6.6 Cross-section of a stream channel. *Figure courtesy of Marin Resource Conservation District, 2007.*

Streamflow in Kelsey Creek lags behind rainfall. On average, substantial precipitation occurs in October (Figure 6.3), and significant streamflow follows in November (Figure 6.7). January is the peak month for precipitation, and streamflow peaks in February.

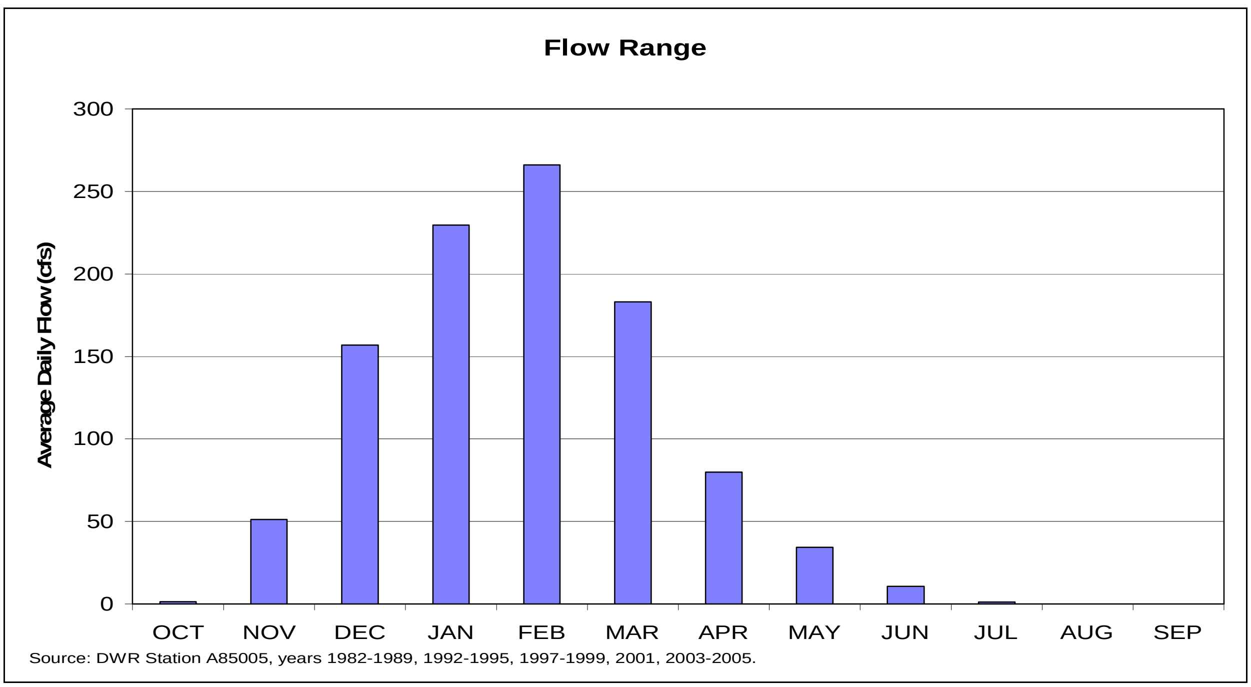


Figure 6.7 Average daily flow rates by month for Kelsey Creek near its mouth at Clear Lake.

6.5 Groundwater

There has been extensive characterization of the groundwater aquifers present in the level alluvial deposits of Big Valley and in the uplifted alluvial deposits immediately to the south. There is little information on groundwater present in the rock formations and small alluvial basins at higher elevations.

There are two principal aquifers that underlie the level floodplain of Big Valley. These aquifers consist of relatively more permeable floodplain and channel alluvium carried into the basin by the flow of Adobe, Highland, and Kelsey Creeks. The lower aquifer is mostly confined or semi-confined, with an intervening clay-rich layer between it and the upper aquifer. The upper aquifer is largely unconfined except to the north where it is covered by lake deposits. Recharge of these aquifers in the area of Kelsey Creek occurs mostly from the channel of Kelsey Creek over the unconfined portion of the upper aquifer. This reach starts near Kelseyville and continues two miles northward. In addition, a limited amount of underflow from Adobe Creek, the upland to the south, and Mt. Konocti contributes to recharge (SMFE 1967). Late in the irrigation season, deep draw-down in the Kelseyville formation to the south, may reverse the direction of the underflow (Christensen Associates Inc. 2003).

To the south, the uplifted Kelseyville formation contains two aquifers. The upper aquifer consists of stream deposits and is largely unconfined. It is recharged by the surface flow of Kelsey Creek south of Kelseyville and by percolation of rainfall. The lower aquifer is a narrow volcanic ash aquifer. Recharge of the volcanic ash aquifer is poorly understood, but is likely to be by underflow from adjacent uplands (Christensen Associates Inc. 2003).

The California Department of Water Resources (DWR) has estimated total groundwater storage in Big Valley to be 105,000 acre-feet. Usable groundwater storage, the quantity of water that can be withdrawn annually without causing adverse conditions, is estimated to be 60,000 acre-feet (CDM and DWR 2006b).

7.0 Hillslope and Stream Channel Geomorphology

7.1 Soil Erosion and Sedimentation

Erosion is a natural geologic process. Through erosion, hills and mountains are gradually worn down and sediment is deposited in valleys, lakes and bays. Accelerated erosion occurs through human activities such as livestock grazing, cutting forests, plowing sloping land, disturbing land for construction of roads and buildings, stream channelization and development that reduces land permeability and concentrates streamflows. Accelerated erosion leads to soil degradation when topsoil is lost and to increased sediment loads in streams and lakes that reduce water quality. (See water quality section below.)

Several factors influence erosion of the soil surface. Surface erosion is generally inconsequential on level ground and increases as the slope of the land increases. There is also greater erosion potential as the length of sloping ground increases. The amount and intensity of rainfall influence erosion as do soil properties such as texture and permeability. Cover by vegetation or other materials has a major influence on soil erosion. Bare soil is much more likely to erode, and covering it with living vegetation, mulches or other materials is one of the best erosion control methods. Other soil conservation practices include contour tillage and construction of terraces.

Landslides are the down slope movement of large masses of sediment and rocks, largely due to gravity. They can be set off by natural causes such as heavy rainfall, earthquakes, floods, and by human activities such as grading, terrain cutting, and filling. Three factors contribute to the potential for landslides, the steepness of the terrain, consolidation of the materials that make up the slope, and the amount of water which loosens the materials (USSARTF 2008). Landslides have the potential to cause sporadic, but very large sediment loads to stream systems. No study was found on landslides within the Kelsey Creek Watershed for this assessment.

Roads, especially unpaved roads, can be major sources of erosion from the landscape. There are 172 miles of unpaved roads (includes both rough and unpaved) in the Upper Kelsey Creek Watershed (Plate 7). Surface erosion from roads can be a chronic source of fine sediment. Road failures, especially when large storm events cause multiple failures, contribute large sediment loads to streams. Operation of motorized vehicles off of developed roadways contributes to both hillside and streambank erosion. There is no information on the condition of unpaved roads in the Kelsey Creek Watershed.

Developed areas, even at low densities, contribute to increased long term erosion potential. In these areas, impervious surfaces increase surface run-off, and flows are concentrated in ditches and other water conveyance structures. Streams are frequently channelized, straightened and/or deepened, for development or agricultural purposes. Channelized streams have the potential to carry higher peak flows and therefore greater sediment loads. Higher peak flows also contribute to greater downstream flood potential.

Agricultural tillage both loosens soil and removes soil cover. It increases erosion risk primarily on sloping ground, and the two crops commonly grown on sloping ground in Lake County are walnuts and wine grapes. Hillside walnut orchards are often disked in the spring to remove weeds and preserve soil moisture, and this causes the potential for soil erosion in fall and winter months. Potential erosion in vineyards is greatest during vineyard development when ground is cleared for planting, however mulching and other practices reduce this risk. Once developed, hillside vineyards are generally managed without tillage, using herbicides to control weeds in the vine row and a cover crop in between vine rows that is mowed in the spring.

While livestock grazing can remove vegetative cover leading to erosion on hillsides, the greatest erosion impacts of livestock may be damage and removal of riparian vegetation and streambank erosion.

As discussed in the history chapter, the impacts of human activities on soil erosion in the Clear Lake Watershed became obvious following the advent of heavy earth-moving equipment in about 1927 when sedimentation rates increased approximately 10-fold.

There are numerous resources describing best management practices for road building, construction site, and farming practices to prevent surface erosion and landslides (Appendix D).

7.2 Erosion Hazard Analysis

Two erosion hazard analyses were carried out by NRCS personnel for the Kelsey Creek Watershed. The first was the potential for surface erosion in areas where the land surface has been disturbed, and the second was soil slippage risk. The analyses were done on the Kelsey Creek Watershed without including the expanded area of interest in Big Valley. Details of the data and calculations used to generate the analysis and plates are included in Appendix E.

Surface erosion risk following disturbance (Plate 8) was determined assuming that disturbance activities have exposed 50-75% of the mineral soil surface. These activities could include forestry practices, grazing, mining, fire, firebreaks, etc. The analysis places soils in the following four categories: SLIGHT indicates that erosion is unlikely under ordinary climatic conditions; MODERATE indicates that some erosion is likely and that erosion-control measures may be needed; SEVERE indicates that erosion is very likely and that erosion-control measures, including re-vegetation of bare areas, are advised; and VERY SEVERE indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion-control measures are costly and generally impractical.

Soil slippage risk is the possibility that a mass of soil will slip when these conditions are met: 1) vegetation is removed, 2) soil water is at or near saturation, and 3) other normal practices are applied. Other factors could increase the risk of soil slippage, but they are not considered here. Examples of these other factors are: 1) undercutting lower portions or loading the upper parts of a slope, or 2) altering the drainage or offsite water contribution to the site such as through irrigation. A map of soil slippage risk in the Kelsey Creek Watershed is shown in Plate 9.

Areas with high erosion risk following land disturbance and with high soil slippage risk are concentrated on sloping grounds in the upper watershed, while more level areas in the lower watershed have lower risk (Plates 8, 9).

7.3 Stream Channels

Stream channel form and stream processes tend to change from the headwaters of a stream, creek, or river to its mouth. The longitudinal profile of a stream from its headwaters to outlet can be divided into three zones (Figure7.1). In Zone 1, the headwaters zone, the gradient, or slope of the stream is greatest. This zone is dominated by erosion of sediments, which are transferred downstream. Zone 2, the transfer zone, receives some of the eroded material from Zone 1, and therefore usually has a floodplain and a meandering channel pattern. In Zone 3, the depositional zone, the stream gradient flattens to nearly level and most eroded material is deposited. It is characterized by a broad, nearly flat valley with a meandering channel (USDA NRCS 1998).

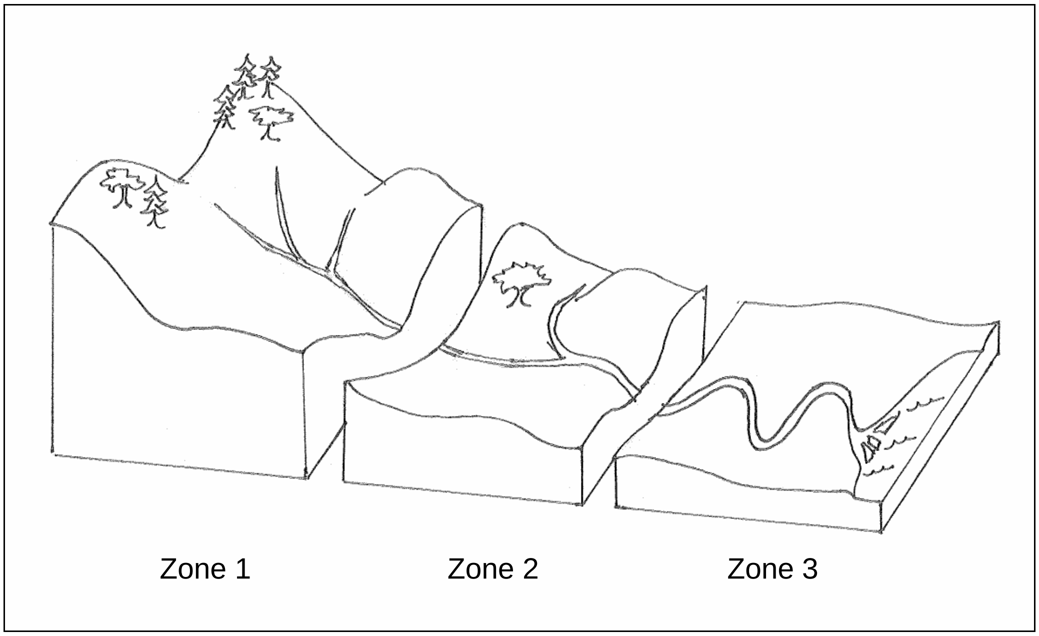


Figure 7.1 Longitudinal profile of a stream.

In Zone 1, stream size is typically small, and streams flow through v-shaped valleys with no floodplains. Therefore the upland plant community is found adjacent to the stream. Where forests occur they may form a canopy over the stream. Stream water temperatures tend to be relatively cold and stable due to groundwater recharge. Zone 2 has a wider channel and more complex floodplain than Zone 1. Plant communities adapted to periodic flooding are present in the floodplain. As the channel widens, the stream is exposed to more sunlight which causes larger daily water temperature fluctuations, and an increase in the average water temperature. In Zone 3 large floodplain wetlands may be present because of the flatter terrain. In addition valley hardwoods create productive and diverse riparian communities in the deep alluvial soils.

Figure 7.2 Headwaters stream from a spring near Cobb. *Photo by Kevin and Jennifer Ingram.*

Figure 7.3 Kelsey Creek flowing through a meadow in the upper watershed (along Glenbrook Dr. behind Jellystone Park, May 3, 2008. *Photo by Kevin and Jennifer Ingram.*

Stream channels often have a naturally occurring sinuous, or curving, channel form (Figure 7.4). Sinuosity tends to be low to moderate in Zones 1 and 2 and moderate to extremely sinuous in Zone 3 (Figure 7.1). The sinuous pattern creates diverse aquatic habitats with an alternating series of pools at the bends of the watercourse and riffles (shallow, gravelly areas) in between the bends. The stream form is dynamic with the curves and channel migrating over the floodplain. This movement of the stream channel creates a diverse riparian community with both older stages of vegetation on the outer curves, and new stages on the newly deposited point bars on the inside of the curves (USDANRCS 1998). Large woody debris contributes to pool formation and supports high densities of aquatic macroinvertebrates that are an important food source for fish (Leopold, L.B. 1997, NRCS 1998). In their natural state, many streambanks are heavily vegetated. This vegetation moderates temperatures and is an important source of food to aquatic systems, and is valuable terrestrial wildlife habitat.

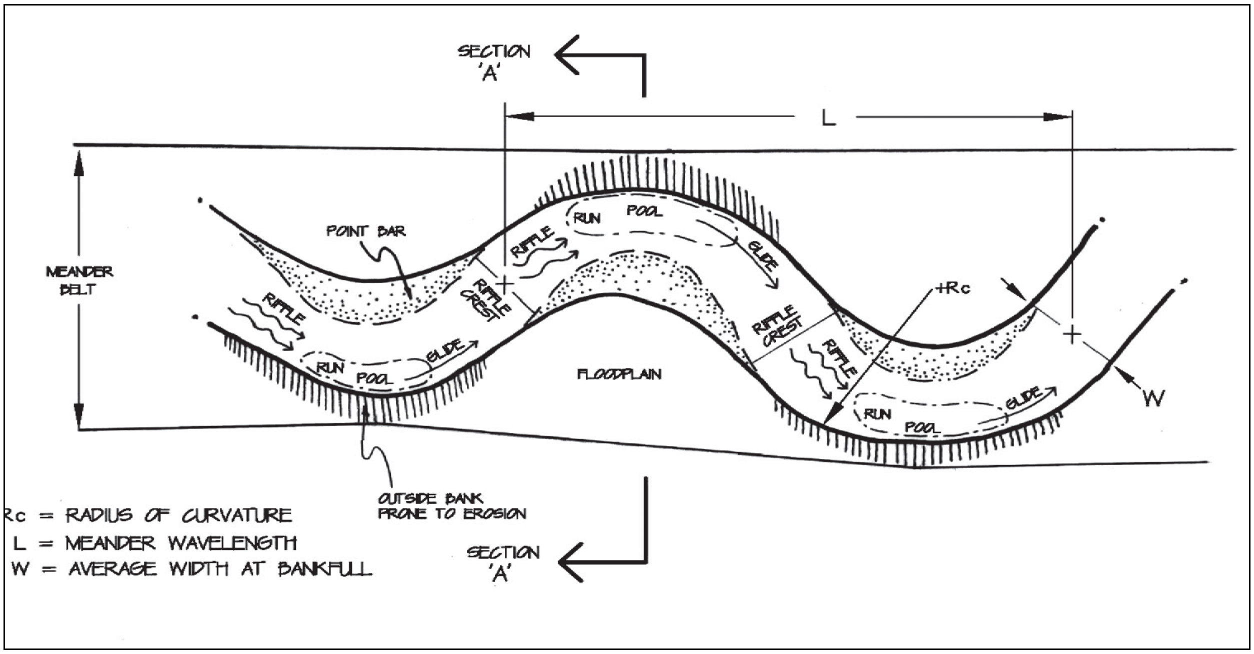


Figure 7.4 Stream pattern. *Figure courtesy of Marin Resource Conservation District, 2008***.**

Many flood control practices alter stream channels and reduce habitat values for aquatic and terrestrial wildlife. Straightening and deepening, or channelization, of streams and rivers is often done for flood reduction. Stream channels are also straightened to "square up" agricultural fields and roads. Straightening disrupts the pool and riffle sequences that are important components of aquatic habitat. It also increases the velocity of water moving through the stream channel, which can lead to increased scouring and channel deepening. Construction of floodwalls and levees can increase stream velocity by constraining high flows to a narrower channel and allowing greater flood heights. Construction of levees also generally involves removal of riparian vegetation that is an important component of aquatic and terrestrial habitats. Another flood control practice is removal of large, woody debris because it increases flood levels upstream of the obstruction.

Water diversions for irrigation and other purposes reduce streamflows and may obstruct fish passage. Reduced water availability can have detrimental effects on water quality and aquatic organisms as discussed below in the stream water quality section.

In-stream gravel mining involves removal of vegetation, destruction of in-stream habitat, and alteration of the stream channel. Extensive gravel mining can lower stream channels with consequences for groundwater tables and recharge. (See Lower Kelsey Creek channel conditions and Water Availability, Lower watershed sections.)

Livestock are attracted to streams for water and often for shade. Their use of streams leads to loss of vegetation and increased streambank erosion as well as potential fecal contamination of water.

Several land use activities have the potential to reduce soil permeability and water infiltration. During storm events, this leads to increased run-off, and more gradual water delivery through the soil profile to streams is reduced. Reduced soil permeability therefore leads to more "flashy" streamflows with higher flood peaks, greater erosion potential, and reduced sustained flows. Urban areas with impermeable surfaces contribute to flashy streamflows. Forestry, livestock grazing, and agricultural practices have the potential to reduce soil permeability, although management practices can lower or eliminate this potential.

7.3.1 Kelsey Creek Stream Channel Studies

Stream channel conditions of Kelsey Creek and some of its tributaries were noted in stream surveys carried out by the California Department of Fish and Game and the United States Bureau of Land Management on Kelsey Creek and several of its tributaries from 1958-1977 (DFG 1958, 1970a, 1970b, 1970c, 1973, 1974a, 1974b, BLM 1973a, 1973b, 1975). More recently, the Lake County Planning Department surveyed portions of Kelsey Creek as part of the Aggregate Resource Management Plan (ARMP) (Lake County Planning Department, 1992). This survey divided streams into sections with similar channel and vegetation conditions and provided detailed descriptions of the channels, vegetation, and adjacent land use. Findings from the ARMP are included below, however, a long period of time has elapsed since the survey was completed during which substantial change is likely to have occurred.

7.3.2 Lower Kelsey Creek Channel Conditions

Gravel mining and the alteration of the mouth of Kelsey Creek caused major changes in the lower Kelsey Creek channel (Table 7.1). Along Kelsey Creek the most significant area of gravel extraction was from the town of Kelseyville continuing about 1.5 miles to the north. A series of aerial photographs shows several major changes (Appendix F). In 1940, the creek meandered across its entire floodplain in the stream section between Merritt and Big Valley Roads. Possibly due to gravel mining and deepening of the channel, it was confined to a narrower area to the east by 1952 and in subsequent photos. There appeared to be almost no riparian vegetation throughout most of the floodplain through 1970. There was very limited vegetation by 1984 and a substantial increase in riparian vegetation north of Highway 29 in the 2005 photo.

Table 7.1. Major alterations to lower Kelsey Creek and their time of occurrence.

Time of occurrence	Stream alteration
Until 1980	Gravel mining below Main St. Bridge*
Until 1987	Gravel mining Sweetwater Creek to Main St. Bridge**
1962	Channel straightened and deepened at mouth
1987	Detention structure constructed

*Moratorium on mining in 1981.
**Moratorium on mining in 1992.

The area where major gravel mining occurred coincides with much of the groundwater recharge area for Kelsey Creek. The recharge area starts approximately 2,500 feet south of the Highway 29 bridge and extends 2.5 miles to the corner of Finley East Road. Starting in the 1960s, gravel mining operations and modification of the mouth of Kelsey Creek contributed to channel lowering of about 10 feet in this area.

> "Formerly, the channel was only a few feet below the general level of the plain, and the stream flowed in any, or all, of several courses, which shifted back and forth over an area of up to 1,500 feet width. This condition frequently led to flooding of the area around and within Kelseyville, but it also provided a much larger area for the first stages of infiltration from the creek to the aquifers of Kelseyville Basin" (LCFCWCD 1999).

Local resident Carolyn Henderson described how Kelsey Creek used to meander through the town of Kelseyville and adjacent lands. "I can remember when it came through town in several places…It came through our orchards, but it was more or less channeled. As far as I know, it didn't do any great damage…And then they straightened it all out, and then it went swish down to the lake." (Voice recording from Big Valley Watershed Council meeting, March 4, 2008)

In 1962, the mouth of Kelsey Creek was straightened and deepened as part of a project at Clear Lake State Park. Prior to this project, Cole Creek to the east of Kelsey Creek entered Kelsey Creek before Kelsey Creek took a bend to the east and entered the lake to the north of Dorn Cove. Since the mouth of Kelsey Creek was straightened, both creeks now enter directly north to the lake (Aerial photos Appendix F). The straightening and deepening of the mouth of Kelsey Creek created more rapid streamflows, which contributed to stream down-cutting upstream.

Ray Mostin and Don Eutenier, neighbors on either side of Kelsey Creek about 1.8 miles from the mouth, described how the creek bed dropped from 6 to about 26 feet below the banks adjacent to their homes. Don explained that "this all happened during the time of gravel extraction upstream and the straightening and opening of the mouth of Kelsey Creek down at the park" (Voice recording from Big Valley Watershed Council meeting, March 4, 2008).

Figure 7.5 Below the bridge at Soda Bay Rd. the bed of Kelsey Creek has dropped significantly. *Photo by Greg Dills.*

The lower portion of Kelsey Creek from its mouth at Clear Lake continuing upstream approximately 10 miles was surveyed for the Aggregate Resource Management Plan (1992). Overall channel condition in 1992 was described as follows:

> "Kelsey Creek is gradually recovering from serious bank and channel damage. This recovery appears to be the result of natural aggradation and re-vegetation following nine years of mining moratorium, and from channel restoration projects. This recovery has been enhanced by the groundwater recharge structure at Mile 2.45 and by the low water crossing for Merritt Road. Both structures have slowed flows and reduced the channel gradient, thereby increasing aggradation of the channel.
>
> While significant recovery has occurred, far more is necessary. Between Miles 1.2 and 7.0, the creek channel is incised as much as 20 feet below terrace level. According to long-term residents, the channel averaged less than three to five feet in depth in the 1940's" (LCPD 1992).

Between the detention structure and Renfro crossing, four drop structures were created for gravel retention. They consist of a linear arrangement of concrete slabs across the creek bed each creating a structure about 2 feet high. These structures were placed in the creek between 1989 and 1995, and they have since filled in with gravel. This rise in the stream bed replaces some of the groundwater storage lost due to channel down-cutting (Tom Smythe, personal communication).

The drop in the creek channel level after 1960 and the partial recovery following the moratorium on gravel mining in 1981 can be seen from water levels for well number 13N-09W-15B2, located approximately 600 feet north of Kelseyville Main Street and 320 feet laterally from Kelsey Creek. This well is in hydrologic contact with Kelsey Creek, so the well surface level corresponds to the water level in Kelsey Creek. Spring well levels, shown in Figure 7.6, show an approximate 15 foot drop in the level of Kelsey Creek by the 1970s, and a rise of about 3 feet after 1987.

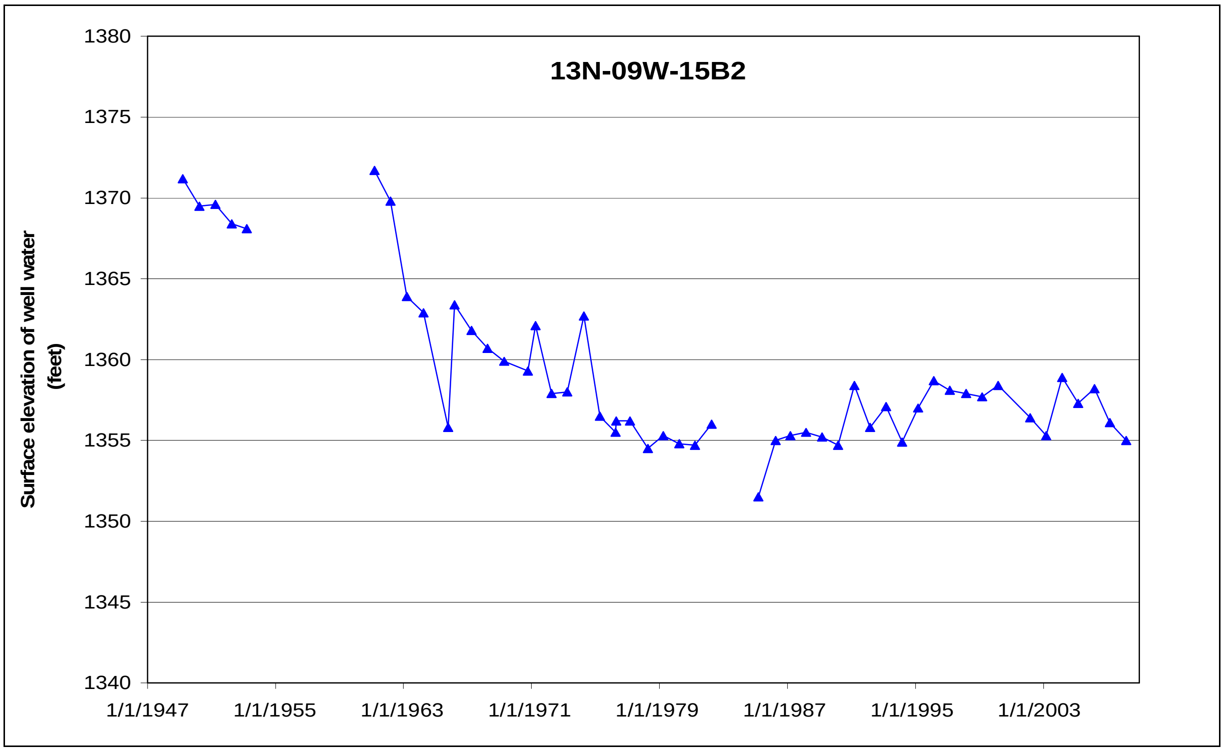


Figure 7.6 Spring water levels for well number 13N-09W-15B2.

Peter Windrem, who lives about 1.7 miles upstream of Kelseyville, described head-cutting that occurred due to the lowered stream channel downstream. “When we first moved there, our creek had pools, trees along the edges, alders, and then it changed radically…We’ve lost 8-10 feet of vertical distance of gravel in that area. It scoured out, dropped down to the clay to the point where it might as well have been a Los Angeles aqueduct.” This period of head-cutting occurred from approximately 1976 to 1986 according to Windrem, and since then conditions have improved. “The alders... and the willows have been coming back in the stream, and they’re starting to catch the gravel, and it’s beginning to build back up some, and it’s cooler. Now we’re starting to see some wildlife come back." (Voice recording from Big Valley Watershed Council meeting, March 4, 2008).

Gravel mining upstream of this section was also occurring in the 1970s and continued until a moratorium in 1987. A comparison of 1984 with 2005 aerial photographs from the area where Sweetwater Creek joins Kelsey Creek to just above the gorge (5.5 to 4 miles above Kelseyville) shows much improved vegetative cover by 2005 (Appendix F).

Residents who live near the mouth of Kelsey Creek on Steelhead Drive remember that in the late 1960s that the channel near the mouth was deeper, and there was less riparian vegetation along it. These residents would prefer that the channel be dredged to maintain boat access, improve the view to the lake, and improve fishing conditions (Clements, undated).

7.3.3 Upper Kelsey Creek Channel Conditions

As part of the ARMP, Kelsey Creek was surveyed in 1985 from its intersection with Highway 175 downstream 5.5 miles. The survey found evidence of channel down cutting and bank erosion only in a one mile section of open meadow where riparian vegetation had been removed. This section began 1.2 miles downstream of the Highway 175 stream crossing. "Elsewhere the creek channel remains in excellent condition. The bed is composed largely of cobbles and boulders and is highly resistant to erosion and downcutting" (LCPD 1992).

7.4 Flooding and Floodplain Management

Flood zones are mapped by the Federal Emergency Management Agency (FEMA) as part of the National Flood Insurance Program (NFIP), and 1% and 0.2% annual chance flood zones for Kelsey Creek and Big Valley are shown in Plate 10. The 1% annual chance flood means that there is an estimated one percent chance of a flood in any given year. A common way of referring to the 1% annual chance flood zone is the 100 year flood zone, because on average, a flood occurs once every 100 years in this zone. On average, a flood would occur once every 500 years in the 0.2% annual chance flood zone. Flood Zone D is the area of undetermined flood hazard, and flood Zone X is an area with 0.2% annual chance flood or 1% annual chance flood with less than one foot water depth. As more information on flooding is gathered, these flood zones need to be updated. As discussed below, flooding is more frequent than currently mapped for some areas, and in other areas flood frequency is less than currently mapped (Tom Smythe, personal communication.)

In the mapped portion of the upper watershed, the width of the FEMA mapped floodplain ranges from about 150-450 feet. In the lower watershed, flooding again occurs in a narrow area along the creek to the south of Kelseyville. In Big Valley the 1% and 0.2% annual chance flood zones cover large portions of the Valley.

The Lake County Flood Management Plan discusses two areas in the Kelsey Creek Watershed with significant flooding issues. The floodplain near Sweetwater Creek has been found to exceed the mapped floodplain in some locations, and more recent analysis indicates a flood frequency of approximately 20 years (5% annual chance flood). Ten to fifteen homes are subject to flooding in this area and vehicular access is cut off to some properties on the east side of the creek during high flows (Lake County 2000).

North of the Sweetwater Creek area, Kelsey Creek remains confined to a fairly narrow floodplain until approximately one mile north of Kelseyville. Here the creek overflows its banks generating sheetflows across Big Valley. Recent flood frequency analysis indicates that these overflows occur with a 15 year frequency (Lake County 2000). The Lake County Floodplain Management Plan found that "the overflow areas place approximately 30 residential, commercial, and agricultural structures at risk." In addition, several hundred acres of agricultural lands are subject to flooding; however, the shallow depths, low velocities, and short period of flooding cause little damage (Lake County 2000).

7.5 Debris Jams

Fallen trees and lodging of large woody or man-made debris across a creek can cause serious localized flooding and streambank erosion. Debris jams are more likely to occur in areas where channel size is restricted, such as at bridge crossings. Debris is also more likely to collect, and floods to spread more widely, in areas with a low stream gradient and level floodplains.

While landowners may need to remove debris jams to protect their property, flooding and debris jams are also a part of natural stream processes. Shifting stream channels lead to a mosaic of riparian habitats supporting diverse vegetation and wildlife. Large woody debris is important habitat that helps to form natural dams and pools. Where possible, land use patterns should include building set backs and floodplain compatible activities, such agriculture or recreation, in order to allow natural stream processes to occur without excessive property damage.

The Big Valley Watershed Council toured sections of Upper Kelsey Creek on May 3, 2008 to view stream conditions. The group observed debris jams and streambank erosion (<u>Figures 7.7</u> and <u>7.8</u>). The group concluded that there was a need for hydrologic studies to determine whether these conditions were caused by current land use activities, and there was a need to continue monitoring stream conditions (Kevin Ingram, personal communication).

Figure 7.7 Fallen trees create potential debris jam in Upper Kelsey Creek. *Photo by Robert Stark.*

Figure 7.8 Streambank erosion in Upper Kelsey Creek, May 3, 2008. *Photo by Jennifer and Kevin Ingram.*

8.0 Water Quality

8.1. Stream Water Quality

Physical, chemical, and biological stream characteristics of Kelsey Creek are inherently different in the upper and lower portions of the watershed. In the upper watershed, Kelsey Creek and some of its tributaries are cold, rapid flowing streams suitable for trout. Rapid streamflow helps maintain lower water temperatures and higher dissolved oxygen levels. Rapid flows also help to flush organic materials, sediment, and nutrients that contribute to bacterial, algal, and plant growth, and high biological oxygen demand. In general, headwater streams will have lower concentrations of dissolved chemical compounds than streams lower in the watershed because evaporation causes the chemicals to become more concentrated (Harrington, J. and M. Born 2000). In the lower watershed, the stream gradient is more gradual, and flows are slower leading to warmer conditions suitable for warm water fish species.

Human activities have the potential to alter stream conditions, frequently in ways that harm aquatic ecosystems. Activities such as timber harvesting, construction, and agriculture contribute increased sediment loads to streams. Although suspended sediment can harm fish directly, the greatest harm to aquatic ecosystems comes from deposition of sediment on the stream substrate. Sediment can fill in gravels needed for spawning and can smother the habitat needed by insects and other organisms that are the food source for fish (Harrington, J. and M. Born 2000).

Nutrient sources such as sediment, animal waste, sewage, and fertilizer stimulate algae and plant growth in a process called eutrophication. Eutrophication decreases the diversity of aquatic life because organisms that function as collectors and filterers come to dominate the food web. When the large amounts of biomass produced by eutrophication begin to decompose, oxygen levels can drop and cause die-offs. Eutrophication also increases turbidity or cloudiness of the water (Harrington, J. and M. Born 2000).

There are numerous toxic pollutants that can enter streams from industrial, agricultural, urban, or municipal wastewater sources. These include metals, such as mercury, lead, or copper; organic compounds, such as petroleum and many pesticides; anions, such as fluoride and cyanide; acids, and alkalis that affect the pH of water; and gases, such as chlorine and ammonia (Harringtion, J. and M. Born 2000).

Temperatures are altered by removal of tree canopy or alteration of the streamflow regime. The maximum amount of oxygen that can be dissolved in warm water is lower than that in cold water. Biological activity also speeds up with increasing temperature, therefore biological demand for oxygen increases as water temperature increases.

Reduced streamflows due to lower ground water tables and water diversions contribute to the water quality problems discussed above by increasing contaminant concentrations and raising water temperatures.

8.1.1 DWR Stream Water Quality Samples

DWR carried out extensive stream water quality monitoring in the Kelsey Creek Watershed. Most of the sampling was done at 14 locations in the upper

[6] Using GIS systems, coordinates of longitude and latitude can be projected, superimposed, on a map such as a digitized topographic map or aerial photograph.

watershed on Alder Creek, Kelsey Creek, High Valley Creek, and Sulphur Creek from 1978-1987 in association with DWR ownership of the Bottle Rock Power Plant. Sampling was also performed at a location named "Bottle Rock Power Plant near Glenbrook." Sampling was conducted on Kelsey Creek in the lower watershed at two locations in Big Valley and in the canyon where Kelsey Creek begins to climb about 3 miles south of Highway 29. In the lower watershed there were a few samples during the 1930s-1970s, and some continued until 2001.

For this summary, constituents and parameters measured in the DWR samples are compared to current water quality standards (CVRWQCB 2008), and exceedances of the standards are reported. The results are separated based on the type of standard that was exceeded. Primary drinking water standards are legally enforceable standards that apply to public water systems. They are used to protect public health. Secondary drinking standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. Other standards included here are for agricultural water use and fish. Some of these water constituents and parameters can be removed or modified by treatment processes installed by drinking water purveyors or homeowners.

The DWR data was separated into two sets. The first set (Table 8.1) is from the 17 locations apparently sampled from creeks and a spring. Each of these locations has the word creek or spring in its location name. It is likely that samples taken from the location named Sulphur Creek Spring near Glenbrook were taken in or near a spring because this location, sampled only once, had the highest levels of boron, chloride, sodium, total alkalinity, and specific conductance of tge 17 locations included in Table 8.1. The second data set (Table 8.2) is from the location named "Bottle Rock Power Plant near Glenbrook" because it is suspected that it is not a streamwater sample, and may be a sample from a wastewater pond for the power plant. This one location has many more primary drinking water exceedances (50) than the other 17 locations combined (8). In an attempt to precisely locate the sampling locations, geographic coordinates were requested and received from DWR. In many locations they project[6] approximately 100 yards from the streams. The Bottle Rock Power Plant location projects near a pond and a small stream bed below the Bottle Rock Power Plant. DWR staff were contacted, but they were unable to give any explanation beyond the geographic coordinates. Further monitoring of stream water quality above and below the Bottle Rock Power Plant is needed to determine whether there is a problem with contaminants from the plant entering surface waters.

Table 8.1. Summary of water quality exceedances for DWR stream water samples in the Kelsey Creek Watershed (Bottle Rock Power Plant not included.)

Drinking Water Standard Exceedances

Constituent/Analyte (units are mg/L unless otherwise noted)	Maximum	Drinking Water Standard	Exceedance Count	Sample Count
Cadmium (dissolved)	0.01	0.005	5	20
Cadmium (total)	0.01	0.005	1	103
Lead (total)	0.07	0.015	2	109

Secondary or Taste & Odor Drinking Water Standard Exceedances

Constituent/Analyte (units are mg/L unless otherwise noted)	Maximum	Drinking Water Standard	Exceedance Count	Sample Count
Ammonia (total)	3.4	1.5	3	66
Chloride (dissolved)	332	250	1	607
Sodium (dissolved)	220	30	2	655
Iron (total)	1.542	0.3	13	149
Manganese (total)	0.54	0.05	9	160
Specific Conductance 25^{o}C (umhos/cm)	2230	900	1	185

Fish, Aquatic Life, Agriculture Standards Exceedances

Constituent/Analyte (units are mg/L unless otherwise noted)	Maximum	Standard *,**,***	Exceedance Count	Sample Count
Ammonia (dissolved)	0.68	0.401-6.67*	1	44
Ammonia (total)	3.4	0.401-6.67*	6	66
Boron (dissolved)	25	0.7**	4	601
Chloride (dissolved)	332	106**	1	607
Manganese (total)	0.54	0.2**	2	160
Sodium (dissolved)	220	69**	2	655
Specific Conductance 25^{o}C (umhos/cm)	2230	700**	2	185

* Range for fish at early life stages depending on temperature and pH.
**Agricultural water quality.

Table 8.2. Summary of water quality exceedances for DWR samples at the Bottle Rock Power Plant.

Drinking Water Standard Exceedances

Constituent/Analyte (units are mg/L unless otherwise noted)	Maximum	Drinking Water Standard	Exceedance Count	Sample Count
Arsenic (dissolved)	0.013	0.01	1	2
Arsenic (total)	0.71	0.01	27	31
Chromium (total)	0.1	0.05	3	15
Lead (total)	0.02	0.015	1	31
Mercury (total)	0.963	0.002	14	33
Sulfate (dissolved)*	791	500	4	32

*Unclear whether Sulfate as SO_4 or S.

Secondary or Taste & Odor Drinking Water Standard Exceedanc

Constituent/Analyte (units are mg/L unless otherwise noted)	Maximum	Drinking Water Standard	Exceedance Count	Sample Count
Ammonia (dissolved)	174	1.5	25	25
Chloride (dissolved)	332	250	1	28
Sodium (dissolved)	184	30	1	31
Sulfate (dissolved)*	772	250	10	32
Iron (total)	38	0.3	25	32
Manganese (total)	0.76	0.05	14	30
Specific Conductance 25^{o}C (umhos/cm)	2030	900**	10	31

*Unclear whether Sulfate as SO_4 or S.

**Recommended level is 900, upper level is 1600.

Fish, Aquatic Life, Agriculture Standards Exceedances

Constituent/Analyte (units are mg/L unless otherwise noted)	Maximum	Standard *,**	Exceedance Count	Sample Count
Ammonia (dissolved)	174	0.401-6.67*	25	69
Boron (dissolved)	151	0.7**	31	31
Manganese (total)	0.76	0.2**	3	28
Specific Conductance 25^{o}C (umhos/cm)	2030	700**	14	31

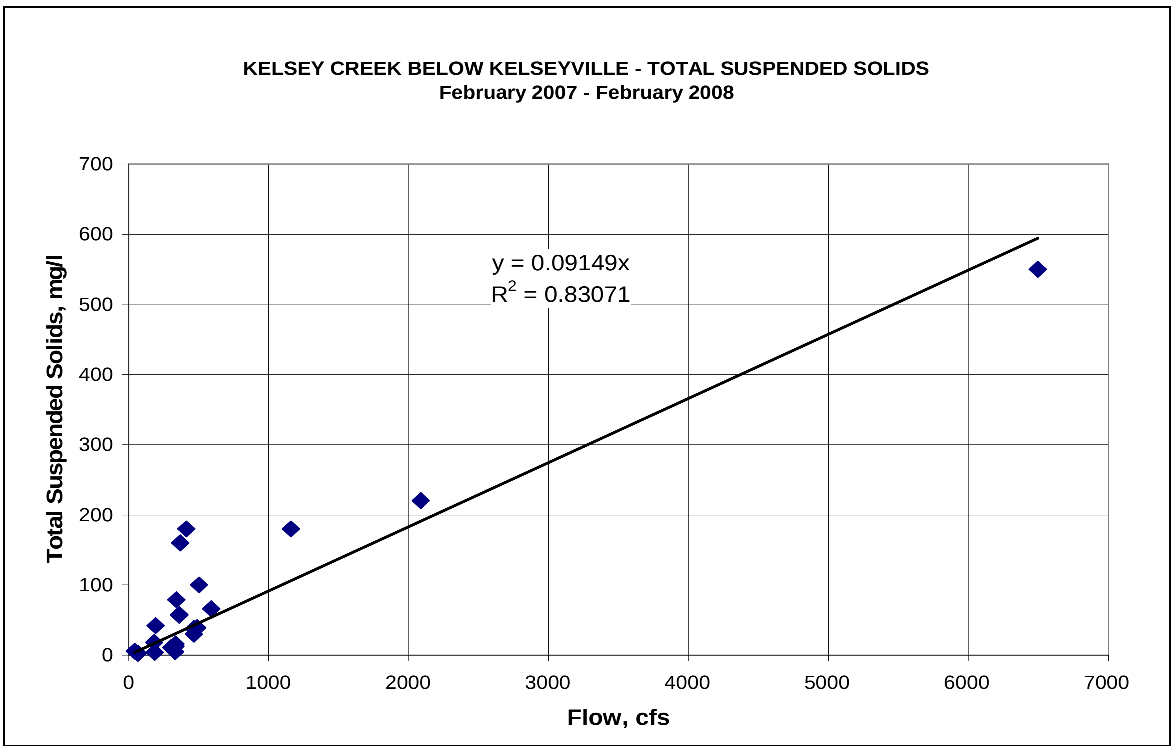
* Range for fish at early life stages depending on temperature and pH.

**Agricultural water quality standard.

8.1.2 Watershed Loading Estimates

A major emphasis of water quality studies on Kelsey Creek has been on nutrients, sediment and mercury because these constituents contribute to impaired water quality in Clear Lake. (See Clear Lake water quality section below.) Samples are taken near the permanent stream gages to determine a relationship between streamflow rate (discharge) and the amount of sediment or nutrients suspended in the water. These relationships can then be used along with streamflow data to estimate the total amount (loading) of a constituent being transported by the stream. Because of the great variability of rainfall patterns in California, it is necessary to continue these studies over many years (Florsheim J. 2007). The studies are also continued in order to find out whether nutrient and sediment transport is changing due to changing land management practices.

As part of a UC Davis study, water was sampled during the winters of 1991-1992 and 1992-1993 at the DWR gages on Kelsey, Scotts, and Middle Creeks. Although the number of samples in this study was small (seven, six, and six for Kelsey, Middle and Scotts Creeks, respectively) the information was used to estimate phosphorus and sediment inputs to Clear Lake (Richerson *et al*. 1994). The Lake County Department of Public Works carried out further sampling on Kelsey, Scotts, and Middle Creeks from 1992-1998. Parameters measured were temperature, pH, conductivity, total solids, dissolved solids, orthophosphate, and total phosphorus. In 2007-2008, additional sampling was carried out. The 2007-2008 total suspended solids and total phosphorus data for Kelsey Creek are shown below in Figures 8.1 and 8.2. In all cases, the sampling studies found that the concentrations of sediment and phosphorus increased as streamflows increased.

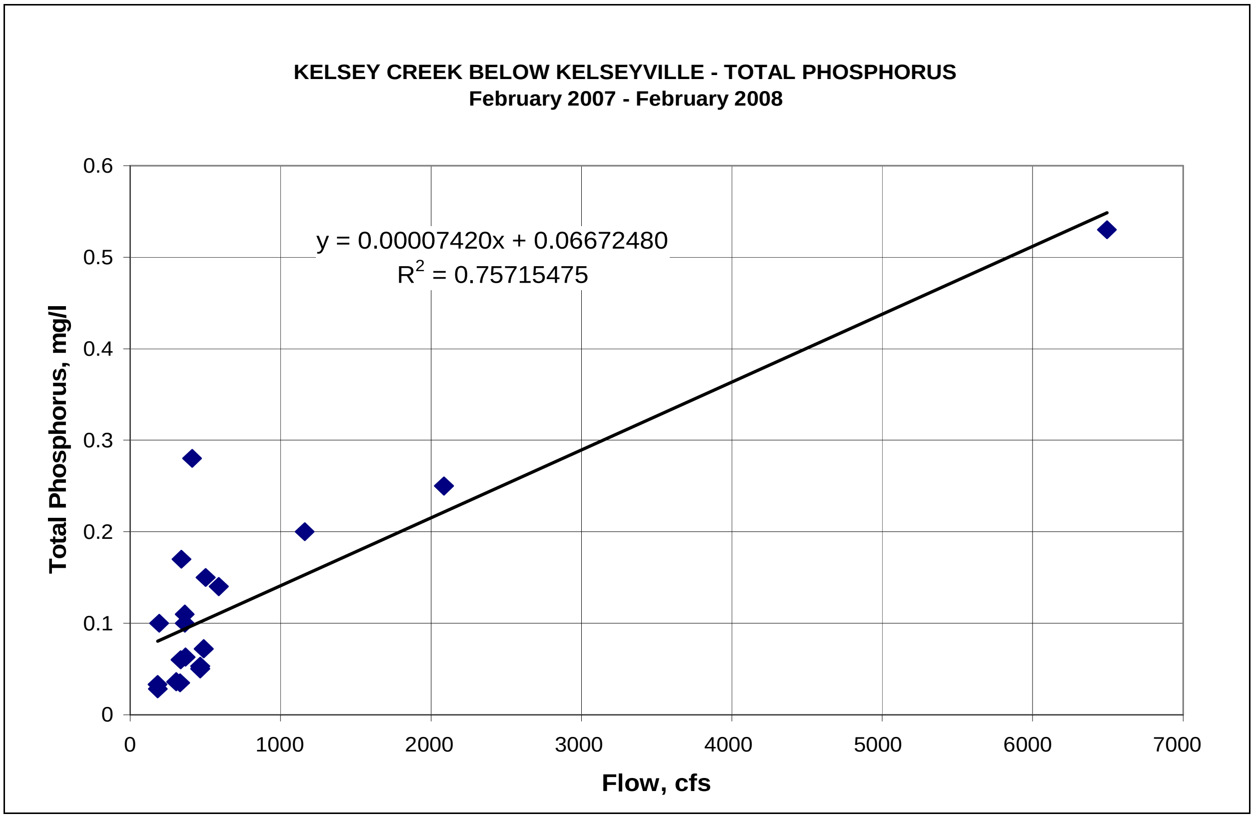


Source: Lake County Department of Public Works, Water Resources Division

Figure 8.1 Relationship between sediment and streamflow in Kelsey Creek.

Other parameters measured in 2007-2008 include iron, methyl and total mercury, chloride, sulfate, and several forms of nitrogen (LCWPD 2009). Based on a significantly greater number of samples, this study found somewhat lower estimates of methyl and total mercury coming from the

Kelsey Creek Watershed than those estimated for the Mercury TMDL. (See section 8.3.) The 2007-2008 monitoring program also included sediment sampling in water courses to look for possible mercury hot spots; however, none were found in the Kelsey Creek Watershed.



Source: Lake County Department of Public Works, Water Resources Division

Figure 8.2 Relationship between total phosphorus and streamflow in Kelsey Creek.

8.1.3 Pesticide Monitoring

Pesticide monitoring was carried out in 2005-2006 under the state Irrigated Lands Regulatory Program. Most owners of irrigated agricultural lands in Lake County have joined the Sacramento Valley Water Quality Coalition, which is managing the monitoring program. McGaugh Slough, adjacent to Kelsey Creek and entering Clear Lake immediately to the north, was chosen for monitoring because it is surrounded primarily by agriculture without adjacent industrial and residential land uses such as those present on Kelsey Creek.

Tests were made for numerous chemical constituents, including 70 types of pesticides. The tests were carried out on several samples each year. Only one pesticide, the herbicide simazine, was detected on one sample date. The level of simazine was below water quality regulatory thresholds. *E. coli*, a bacterium indicating possible fecal contamination, was also found to exceed regulatory limits. *E. coli* can come from livestock, birds and wildlife, and humans, and tests to determine its source were inconclusive. Toxicity tests on 3 types of aquatic organisms were made on each sample date. On one date, toxicity for *Daphnia* (a tiny crustacean) was detected. A follow-up test with water sampled on this date did not find toxicity (SVWQC 2006).

8.1.4 Bioassessment and Benthic Macroinvertebrate Monitoring

Another approach to monitoring stream habitat health is to monitor aquatic organisms. DWR conducted sampling for benthic macroinvertebrates (BMI) from 1979-1999 at numerous locations in the upper Kelsey Creek Watershed. These samples were made in spring, summer and fall at Alder Creek, High Valley Creek, and three locations on Kelsey Creek.

These samples showed no obvious changes over the years, nor were numbers different among locations, with one exception. The samples from higher to lower elevation on Kelsey Creek showed trends that would be expected from high elevation, colder streams to low elevation, warmer streams. Samples were taken at Kelsey Creek above Glenbrook, approximately 2300 feet elevation, Kelsey Creek above High Valley, approximately 2200 feet elevation, and Kelsey Creek near Kelseyville, approximately 1480 feet. Spring samples, when flows would have been high, showed no consistent differences among the locations. In summer and fall samples, however, the EPT index decreased, the percent dominant taxa increased, and the percentage of stoneflies decreased with decreasing elevation (Figures 8.3 and 8.4). The EPT index is the ratio of the number of organisms in the Ephemeroptera, Plecoptera and Trichoptera orders to the total number of organisms found. EPT organisms are considered to be sensitive to pollution. Therefore a decrease in the EPT index is an indicator of reduced water quality. The percent dominant taxa is the percentage of organisms in the most abundant group or taxon relative to the total number of organisms. Therefore as the percentage rises, species diversity is declining. Stone flies are sensitive to water quality, especially to sediment which fills in gravels and smothers them. A decline in their numbers indicates a decline in water quality.

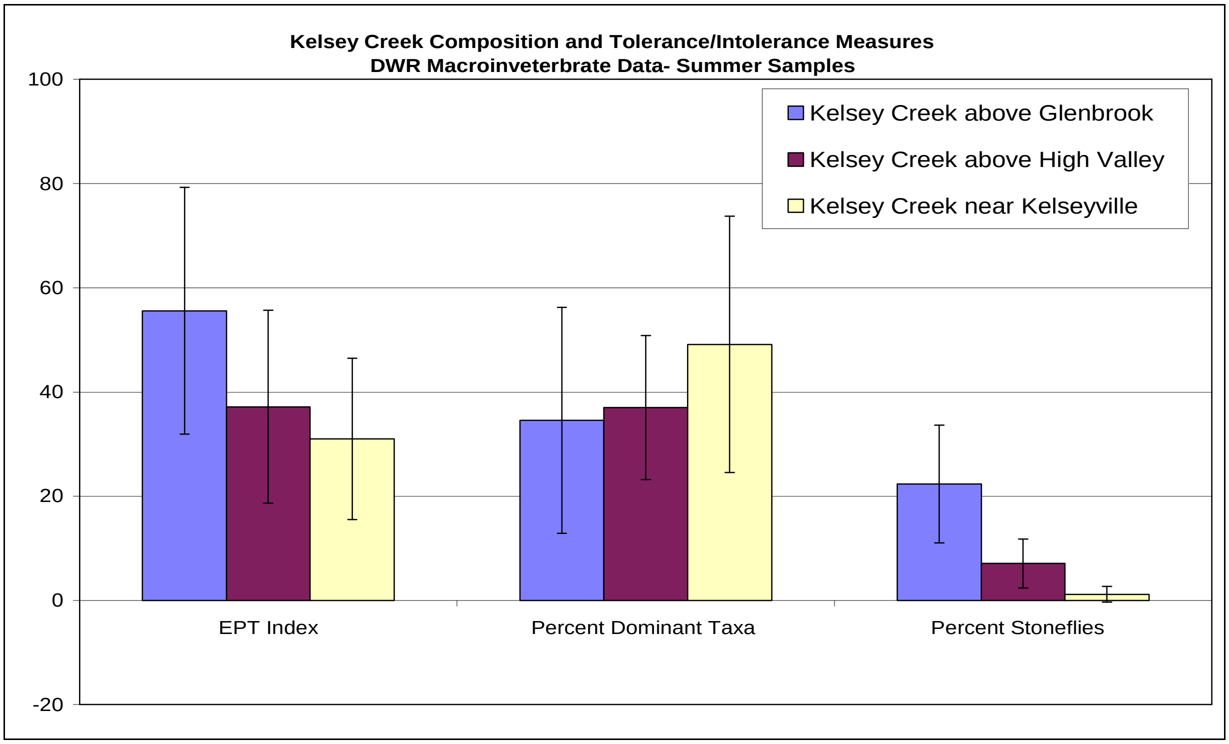


Figure 8.3. Benthic macroinverterbrate community composition and tolerance/intolerance measures for three locations on Kelsey Creek. Values are the mean for 1991-1999 summer samples. Error bars are +/- one standard deviation.

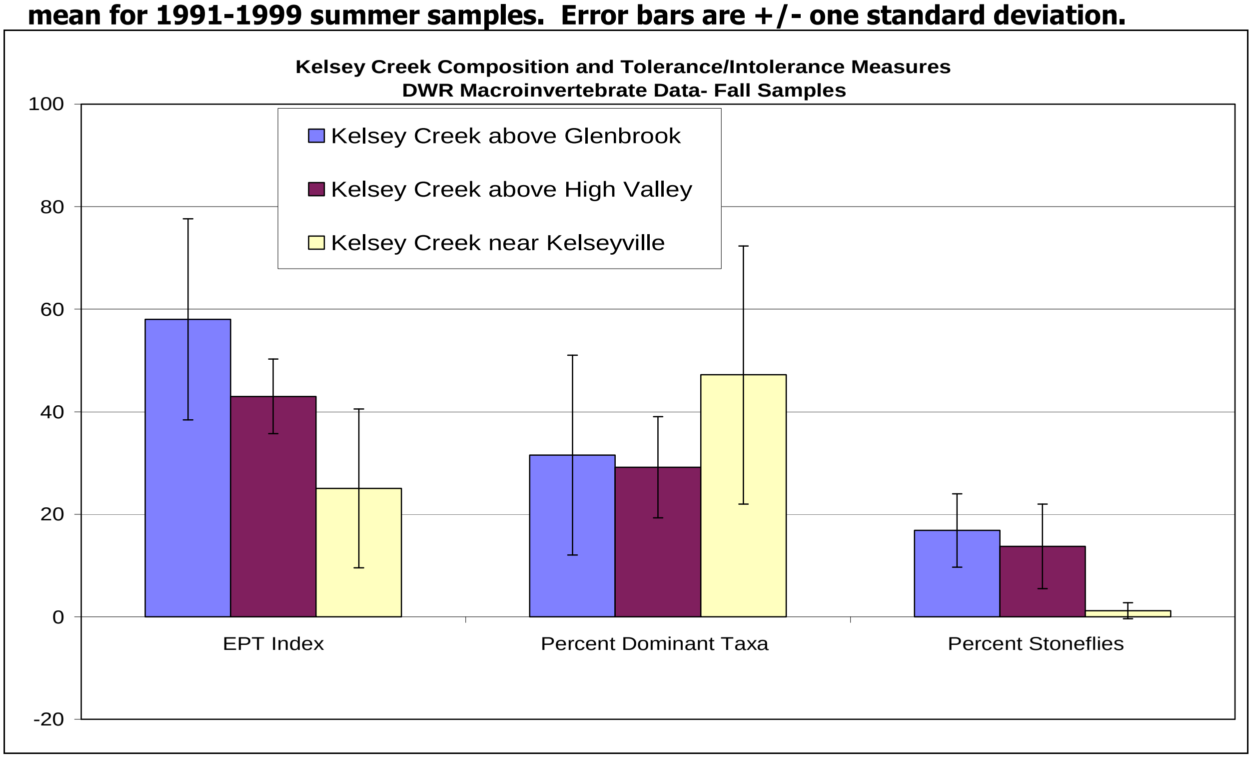


Figure 8.4. Benthic macroinverterbrate community composition and tolerance/intolerance measures for three locations on Kelsey Creek. Values are the mean for 1991-1999 fall samples. Error bars are +/- one standard deviation.

A complete description of the methods and results from the DWR BMI sampling is included in Appendix G. Analysis of the DWR data was performed by staff from the Lake County Department of Public Works, who have had some training in bioassessment monitoring. Additional analysis by a biologist specializing in BMI communities would greatly improve interpretation of the data. A BMI specialist would also be able to determine if and how the data could be used as a baseline for future studies.

Local volunteer water quality monitoring teams, "stream teams" conducted stream bioassessments throughout the county from 2004-2006. Using relatively simple physical and chemical measurements, as well as a biological component, their objective was to gage the ecological health of local stream systems. The advantage to this approach is that "biological and physical assessments are substantially less expensive than chemical and toxicological testing, integrate the effects of water quality over time, are sensitive to multiple aspects of water and habitat quality, and provide the public with more familiar expressions of ecological health" (SLSII 1999). With grant funding from the 319h federal non-point source pollution program, local watershed groups provided training workshops and guidance for the volunteers. The volunteer groups measured streamflow, temperature, dissolved oxygen, pH, conductivity, and turbidity. They sampled and identified benthic macroinvertebrates and made visual observations of stream conditions using the California Stream Bioassessment Procedure in Kelsey Creek on June 13, 2006. The monitoring was conducted in Big Valley about 1,200 feet upstream of the Soda Bay Rd. bridge, in the stream section above the old Quercus Bridge (WLRCD and UPCS 2004). Bioassessment results gave this location in Kelsey Creek a rating of poor relative to the Russian River water quality index, and complete results for the sample are in Appendix H.

8.2. Groundwater Quality

Groundwater quality depends on the quality of water that recharges the aquifers, the chemical properties of the aquifer matrix, and natural or human inputs such as fertilizer and pesticides, septic system leachate, or waste disposal area leachate.

Two recent studies, The Big Valley Groundwater Management Plan (LCFCWCD1999) and the Big Valley Ground Water Recharge Investigation Update (Christensen Associates 2003) described Big Valley groundwater constituents and changes in water quality. These studies found that the dissolved constituents present in the greatest concentrations are magnesium, calcium, and bicarbonate. Of these, magnesium is unusually high in Big Valley groundwater. Other dissolved mineral constituents include sodium, chloride, and sulfate. The total dissolved solids concentration ranges from 350 to 1,200 milligrams per liter (mg/l) and averages 400 to 500 mg/l. Some of these levels were greater than the secondary drinking water standard of 500 mg/l (Lake County Flood Control and Water Conservation District 1998). Secondary drinking water standards are for contaminant levels that affect the odor or appearance of water or cause cosmetic effects.

Big Valley also occasionally has localized problems with geothermal features that contribute high levels of iron and boron and elevated ratios of magnesium to calcium. These locations are often in proximity to inferred fault zones. Boron, which is injurious to many agricultural crops at levels of 0.75 to 1.0 mg/l, is generally present in Big Valley at moderate levels ranging from 0.10 to 0.67 mg/l. However, some wells have levels exceeding 0.75 mg/l, and one had a concentration of 7.28 mg/l (Lake County Flood Control and Water Conservation District 1998). Boron levels have been rising in the western portion of the Kelseyville sub-basin, although the levels are not yet harmful to crops (Christensen Associates, Inc. 2003). The presence of boron may indicate the presence of geothermal waters.

In the Kelseyville sub-basin, nitrate levels have been rising since the late 1950s suggesting nitrate loading from fertilizer or animal/human waste (Christensen Associates Inc. 2003). However, there is insufficient information to identify the source of the nitrate. Nitrate is regulated for human health concerns and has an applicable primary drinking water standard of 10 mg/l N. Levels in some Big Valley wells are approaching 7.5 mg/l N, and one sample was 9.5 mg/l N.

In other aquifers or localized areas, elevated levels of iron, manganese, or hardness may be present (Richerson *et al*. 1994). These constituents do not pose health threats; however some exceed secondary drinking water standards. Increased hardness levels require the use of additional soap or detergents and can increase treatment costs for either homeowners who use water softeners or municipal wastewater treatment plants that must treat the increased rate of waste load in the waste inflow stream.

Recommendations of the Big Valley Ground Water Recharge Investigation Update (Christensen Associates Inc. 2003) include determining whether ground water quality changes as water levels drop seasonally or due to drought. This would be done by expanding and coordinating well water level and quality monitoring.

Since 1983, California state and local agencies that sample wells for pesticides have been required to send their reports to the California Department of Pesticide Regulation (DPR). DPR maintains a database on all pesticide detections in wells. No detections have been reported in Lake County (DPR 2003-2006).

The Lake County Department of Health Services, Environmental Health Division, administers regulatory programs that include components designed to protect drinking water quality. They regulate water well installations, small public drinking water systems (having 5 to 14 connections and serving fewer than 25 people daily over 60 days of the year), on-site septic sewer systems, businesses generating hazardous material and waste, underground storage tanks, and solid waste facilities. Regulation of large public drinking water systems is by the California Department of Public Health. The California Drinking Water Source Assessment and Protection Program requires large public drinking water systems to complete a drinking water source assessment that includes an inventory of possible contaminating activities and a vulnerability ranking to potential contamination (CDHS 1999).

8.3. Clear Lake Water Quality

8.3.1. Nutrients, Algae, and Plants

Clear Lake is naturally eutrophic (high in nutrients, algae, and plant growth), and studies of lake sediment cores indicate that it has supported abundant algal populations for most of its history (Sims *et al.* 1988). Because Clear Lake has abundant algae and plant life, it supports large invertebrate and fish populations in the lake, which in turn feed water fowl and other animals that live around the lake.

Although it is not likely that Clear Lake was ever "crystal clear", it was apparently relatively clear prior to major impacts from land use activities of European settlers. Sediment cores indicate that sedimentation rates to the lake increased dramatically in about 1930 as heavy earth-moving equipment became available (Richerson *et al*. 1994, 2000, 2008). By 1938, severe blue-green algal blooms and insufficient water transparency for rooted aquatic plant growth were documented (Richerson *et al*. 2000). Starting in the 1990s, water clarity improved, and rooted aquatic plants increased in Clear Lake. A severe blue-green algal bloom occurred again during the summer of 2009. This bloom was caused by algae of the genus *Lyngbya*, which previously had not caused significant algae blooms in Clear Lake.

Suspended algae, the tiny photosynthetic organisms floating in the water column, belong to two major groups. One group includes true plants and protozoa. The other group is comprised of bacteria. Thus blue-green algae are also called cyanobacteria. Blue-green algae are bacteria with the capacity for photosynthesis, and they create the most noxious algal blooms.

When severe blue-green algae blooms occur, "the water becomes completely opaque, and the scums resemble thick olive drab paint covering entire beaches and sometimes creating patches thousands of square meters in size in open water" (Richerson *et al*. 1994).

Noxious algal blooms prompted Lake County to seek funding for two major research efforts. The Clear Lake Algal Research Unit, directed by Alexander J. Horne from 1969 to 1976, and the Clean Lakes Study and Clear Lake

Environmental Research Center headed by Peter J. Richerson and Thomas H. Suchanek from 1991 to 2002 investigated the causes and potential controls of nuisance algal blooms.

The researchers focused on what mineral elements are contributing to the high algal biomass. They found that Clear Lake has high phosphorus availability and that most of this phosphorus is transported into the lake attached to sediments. Desirable forms of algae do not grow to high levels because they do not have sufficient nitrogen in the forms they require (nitrate and ammonium). Several common species of blue-green algae, however, can use nitrogen gas present in the atmosphere, and therefore can grow to high levels when phosphorus availability is high. Researchers also found evidence that growth of blue-green algae was sometimes limited by the availability of iron. The main source of iron entering the lake is also sediments.

Because of nuisance algal blooms caused by excess nutrients, Clear Lake was identified as impaired due to nutrients in 1986 under Section 303(d) of the Federal Clean Water Act. This required the Central Valley Regional Water Quality Control Board (CVRWQCB) to establish a Total Maximum Daily Load (TMDL) program to manage the pollutant and ensure the beneficial uses of Clear Lake (CVRWQCB 2006). The nutrient TMDL sets a numeric target for algae levels based on the amount of chlorophyll a, a pigment found in algae. It also mandates a phosphorus load reduction of 40% in order to achieve water quality objectives.

Although the reason for the improvement is not understood, beginning in the 1990s, lake transparency improved and submerged aquatic plant growth increased. The plant growth created congested conditions along the shoreline that restricted swimming, boating, and other recreational activities. Lake County developed an Integrated Aquatic Plant Management Plan (IAPMP), approved in 2005, to support continued multiple uses of Clear Lake, identify environmentally sound and cost effective management approaches, and avoid adverse impacts on humans and non-target plants and animals (Jones & Stokes 2005). Lake County now manages a permit program for aquatic weed control that includes monitoring to insure the proper use of aquatic herbicides and monitor for their fate. Monitoring thus far has shown that herbicides are undetectable one week after application.

8.3.2. Mercury

Mercury is a significant contaminant of Clear Lake waters; however, it is likely that the Kelsey Creek Watershed is only a minor source of mercury. The CVRWQCB estimates that the Sulphur Bank Mine, an open pit mine located on the east end of the Oaks Arm, contributes approximately 97% of the mercury to the lake (CVRWQCB 2002). In 1987 the California Department of Health Services issued an advisory recommending limited consumption of fish from Clear Lake due to elevated mercury levels. Based on this advisory, the CVRWQCB placed Clear Lake on the Federal Clean Water Act 303(d) list of impaired water bodies in 1988, thereby requiring a TMDL program, and the TMDL for Control of Mercury in Clear Lake was approved in December 2002.

As part of the mercury TMDL requirements, the Lake County Watershed Protection District[8] began monitoring for mercury "hot spots" throughout the Clear Lake Watershed in 2006. Both water and sediment samples were collected from streams to determine background levels for sub-watersheds such as Kelsey Creek (SWRCB and LCFCWCD 2005). No elevated mercury levels were found in the Kelsey Creek Watershed (LCWPD 2009).

8.3.3. Aquatic Pesticides

Pesticides applied directly to Clear Lake affect the adjacent watershed through effects on fish and wildlife that inhabit both places. Pesticides were applied to Clear Lake in the past to control the Clear Lake gnat (*Chaoborus astictopus*) and currently to control aquatic weeds. The effort to control the gnat by chemical means was perhaps the "most serious single" human disturbance to the Clear Lake system (Richerson, P.J. and S.O. Richerson 2000) and gave Clear Lake the unfortunate distinction of being included in Rachel Carson's environmental classic, *Silent Spring* (1962). The Clear Lake gnat, whose larvae live in the lake feeding on tiny crustaceans, once emerged as adults in huge numbers. Although the gnats do not bite, they were present in such numbers as to present a nuisance. "Old-timers claim they sometimes accumulated under streetlights in Lakeport to depths of 3 feet" (Richerson, P.J. and S.O. Richerson 2000). After three lakewide applications of DDD to control the gnats in 1949, 1954, and 1957, the population of western grebes in Clear Lake nearly collapsed. Other pesticides were used to attempt to control the gnat, but it appears that biological control by the Mississippi silversides,a fish introduced in 1967, has significantly reduced gnat populations (Richerson, P.H. and S.O. Richerson 2000).

Aquatic herbicides are currently used to control *Hydrilla verticillata*, an aggressive, non-native aquatic plant found in Clear Lake in 1994. Immediately after its discovery, the California Department of Food and Agriculture (CDFA) began a hydrilla monitoring and eradication program in Clear Lake because if left uncontrolled, hydrilla could fill the water body,

[8] Formerly known as the Lake County Flood Control and Water Conservation District.

preventing boating and clogging water intakes. Mechanical weed control spreads hydrilla, so chemical control is required. Herbicides are also used by lakefront property owners to control aquatic weeds. Herbicide use by both CDFA and private property owners requires use permits and pesticide fate monitoring.

9.0 Water Supply

9.1. Upper Watershed

The total available water supply in the upper watershed has not been quantified. Local water districts supply a majority of residents, so their records give an estimate of how much water is currently being used in the upper watershed. Total water production by water providers was 82, 96, and 107 million gallons in 2006, 2007, and 2008, respectively (Table 9.1).

Table 9.1 Water production from wells and springs in the Kelsey Creek Watershed (millions of gallons). Cobb Area, Pine Grove and Cobb Mountain operated by Cobb Area County Water District, Starview operated by Lake County Special Districts Department.

Year	Cobb Area	Pine Grove	Cobb Mountain	Starview	Annual Total
2006	66.6	2.5	1.9	11.0	82.0
2007	75.1	6.5	1.8	12.3	95.7
2008	87.6	5.8	1.7	12.3	107.4

9.2. Lower Watershed

Information on water availability for the entire area of Big Valley will be discussed here, because there are no available estimates exclusively for the area of Big Valley included in the Kelsey Creek Watershed. Estimated water use for the entire area of Big Valley was about 20,550 acre-feet in 2004 (Table 9.2).

Table 9.2 Estimated water use in Big Valley (acre-feet per year).

Water Use Category	Total Water Use[a]	Adjusted total water use[b]
Municipal & Industrial	1,439	1,439
Agricultural	13,416	18,695
Conveyance losses	416	416
Total	15,271	20,550

[a]From Lake County Water Inventory and Analysis Final (CDM and DWR 2006b).
[b]Because above source did not include frost protection, an additional 39% agricultural water use was added based on Big Valley Ground Water Recharge Investigation Update (Christensen Associates Inc. 2003).

Big Valley residents have reported numerous detrimental effects of groundwater overdraft in the past (Tom Smythe, personal communication). The Big Valley Ground Water Recharge Investigation Update lists these effects as potential impacts of groundwater overdraft (Christensen Associates Inc. 2003), and they include:

- Water shortages during droughts that impact agricultural production and local domestic water supplies.
- Deterioration of groundwater quality due to intrusion of geothermal water containing iron and boron.
- Drying up of wells during droughts requiring deepening of wells or new sources of water supply.
- Increases in energy needed for pumping water from deeper levels.
- Ground subsidence, which potentially reduces available groundwater storage and changes surface drainage patterns.
- Impacts on fish, wildlife, and riparian vegetation due to reduced streamflow and earlier drying up of creeks due to lowered water table.

Groundwater storage in the surface aquifer near Kelsey Creek declined as the channel deepened due to gravel mining and alteration of the mouth of the creek. Two well logs, 13N-09W-10E1, located approximately 0.6 miles west of Kelsey Creek on Big Valley Road, and 13N-09W-15B2, located 500 feet north of the Main Street Bridge in Kelseyville, show trends due to channel incision, as well as the effect of major droughts in 1976-1977 and 1987-1992 (Figure 9.1). Levels for both wells were measured in both the spring and fall for most years since 1948, and starting in 1985 well 13N-09W-15B2 was measured on a monthly basis. Well 13N-09W-10E1, further away from the creek, showed a decrease in the spring groundwater level of about 5 feet from the 1950s to 1960s. The effects of the drought years can also be seen with incomplete recharge in the spring and lower well levels in the fall of these years. Significant drought years were 1976-1977 and 1987-1992. Well 13N-09W-15B2 showed a groundwater decline of 15 feet from the early 1960s through 1970s. Gravel mining in this area ceased in 1980, and the groundwater level stabilized.

Following is a brief summary of how water use estimates were made in the Lake County Water Inventory and Analysis (CDM and DWR 2006b). Please refer to the report for additional details. The area of different crops was determined from the 2001 DWR land use survey and was updated for 2004 conditions. DWR values for typical water use of different crops were then used to calculate total water use. Residential water use was calculated by combining census data with per capita water use based on local water purveyor information. DWR information on commercial and industrial discharge permits and golf course acreage was used to estimate water use from these sources. Residential, commercial, industrial and golf course use are combined in the Municipal & Industrial category of Table 9.2.

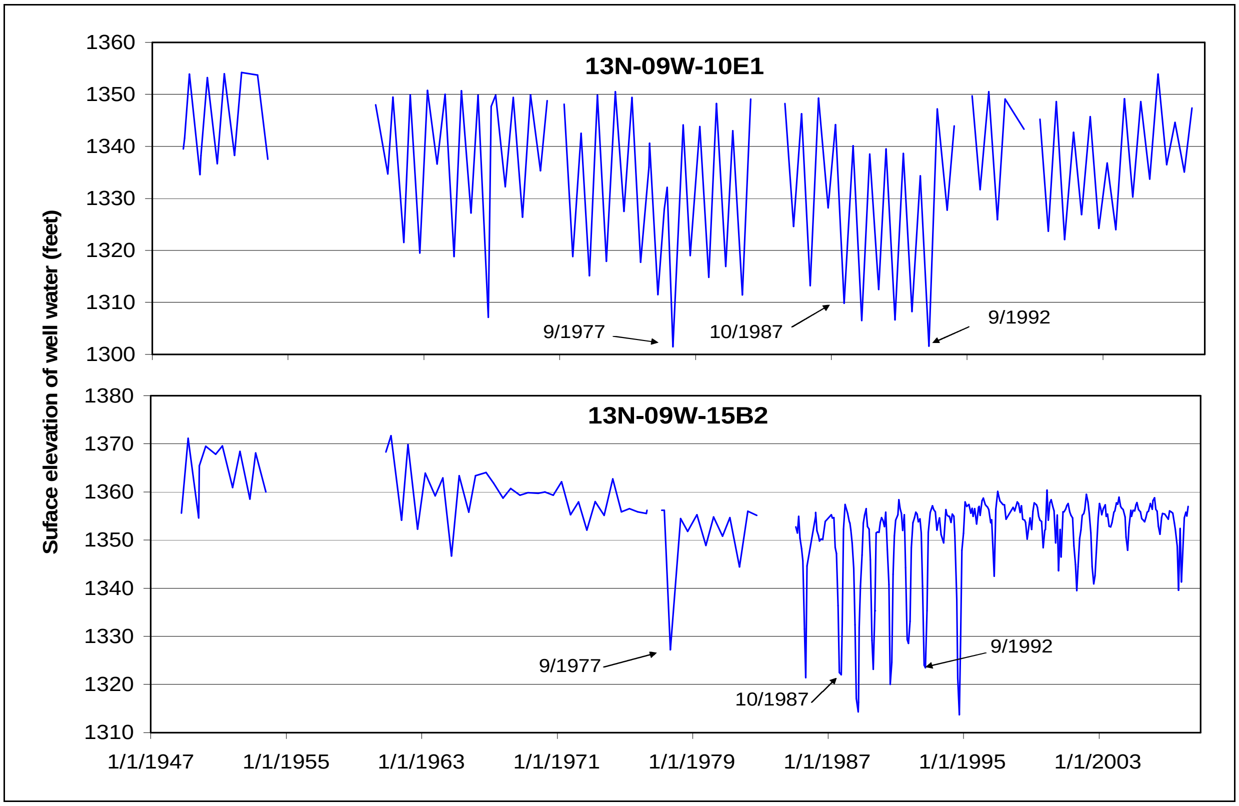


Figure 9.1 Well water surface elevations for two wells near Kelsey Creek in Big Valley.

Agriculture accounted for 88% of water use in Big Valley according to the Lake County Water Inventory and Analysis (CDM and DWR 2006b); however, water use for frost protection was not included. A 2003 study of Big Valley groundwater estimated that frost control increased agricultural water use by 39% (Christensen Associates, Inc. 2003). Using this same percentage with the Water Inventory would increase total agricultural water use by 5,280 acre-feet. Agriculture would then represent 91% of total water use in Big Valley.

In the Lake County Water Inventory and Analysis, surface water was the source for 1,881 acre-feet, or 12% of total water use, and groundwater was the remaining source of water. Water use for frost protection comes from both surface and groundwater, but estimates of the quantity from the different sources are not available.

So far the discussion has covered total water use; however, some surface water is not used and returns to surface water bodies, and some ground water is not used and percolates back to the groundwater table. Both CDM and DWR (2006b) and the Christensen Associates, Inc. 2003 study estimated that net groundwater use was 83% of the total extracted. The CDM and DWR 2006b study estimated that net surface water use was 78% (Table 9.3).

Table 9.3 Sources for water use in Big Valley (acre-feet per year).

Water source	Total Use	Re-use	Net Use	Net Use as % of Total
Surface water	1,881	412	1,470	78 %
Groundwater	13,390	2,229	11,161	83%
Total	15,271	2,641	12,631	83%

Because agriculture is by far the greatest water user in the lower watershed, changes in cropping patterns have a large impact on water use. The first DWR survey of irrigated acreage and other land uses in Lake County was carried out in 1995, and it was repeated in 2001. Between these years, the survey showed a decline of 2,070 acres of deciduous orchards (primarily pears and walnuts in Big Valley), and an increase of 953 and 1,015 acres of idle and vineyard land, respectively (Christensen Associates, Inc. 2003). Since the year 2001, expansion in vineyard acreage has slowed and more pear orchards have been removed. A 2006 land use survey was carried out by DWR, and when that information is available, the extent of these trends can be quantified.

The recent trend from pear orchards to vineyards and idle land has decreased water use. On an area basis, vineyards use about half the irrigation water that pear orchards use (Christensen Associates, Inc. 2003). Christensen Associates, Inc. (2003) estimated that vineyards use approximately 42% less frost protection water on an area basis than do pear orchards. However, their assumptions for frost water application rates to pears appear to be high, and a significant proportion of pear orchards rely on wind machines for frost protection (Rachel Elkins, personal communication). Therefore, rates of frost water use may not differ substantially between vineyards and pear orchards. The 2006 DWR land use survey will be useful for estimating changes in agricultural water use.

In order to give a range of possible long term agricultural water requirements, the Lake County Water Demand Forecast (CDM and DWRa 2006) developed three scenarios for future agricultural water demand (Table 9.4). All three include removal of substantial acreages of pears and walnuts and a large increase in the area of vineyards. Scenario 3 assumes replacement of pear and walnut acreage with crops with a similar water demand. Complete details for the three scenarios are given in Appendix I. The three scenarios estimate a maximum increase in water use of 12% on average years and 14% on dry years. Again frost protection water was not included in the projected water demand estimates.

Table 9.4 Current (2000) and projected (2040) agricultural water demand for Big Valley under three different cropping scenarios.

	Irrigated Cropland (acres)	Average Year Applied Water (acre-feet)	Dry Year Applied Water (acre-feet)
Current (2000)	7,707	13,416	16,091
2040			
Scenario 1	9,057	9,744	12,209
Scenario 2	10,062	11,368	14,184
Scenario 3	10,307	14,956	18,284

Projected urban water demand in 2040 was also calculated in the Lake County Water Demand Forecast (CDM and DWR 2006a). Because population was forecast to increase 63%, urban water demand was forecast to increase by the same amount.

The Big Valley Ground Water Recharge Investigation Update (Christensen Associates Inc. 2003) identified information gaps that limit the accuracy of groundwater size and recharge estimates and recommended additional studies of aquifer properties.

10.0 Terrestrial Habitats and Species

10.1 Natural Habitats

Along the shores of Clear Lake from Clear Lake State Park to Lakeport lies a nearly unbroken stretch of wetland habitat. Only a small portion of these wetlands show in Plate 11, Kelsey Creek Watershed Vegetation, because of the large scale at which vegetation is mapped, 100m X 100m. The Lake County Land Trust (LCLT) has identified this area as "the largest remaining area of unprotected wetland/riparian habitats adjacent to Clear Lake. The shoreline currently maintains high value habitats with pristine lakeshore vegetation and mature oaks used by a variety of species" (LCLT 2008). This shoreline also supports several nesting colonies of Western and Clark's grebes.

In the lowest elevations of the Kelsey Creek Watershed most of Big Valley has been converted to agriculture and residential uses (Plate 11). Valley oak woodlands that may once have covered most of Big Valley are found scattered throughout the valley (mapped as hardwoods in Plate 11). Valley oak woodlands provide nesting sites for cavity nesting birds, and acorns are an abundant food source for many animals and birds (CDFG 1988).

Riparian habitats are found along the shore of Clear Lake and follow Kelsey Creek and its tributaries throughout the watershed. (Riparian areas are not shown on the Plate 11 because their extent is smaller than scale at which the vegetation is mapped.) In their natural state, riparian habitats in valleys have complex, multi-layered tree and shrub canopies that are important to a wide array of wildlife and fish. The natural meandering of streams in nearly level valleys promotes a mosaic of habitat elements. As a stream meanders, it cuts away the banks on the outside of curves, while depositing material on the inside, or point bar. Cutting away the banks tends to destroy mature forest stages, while on the point bars new stages begin with colonization by willows, sedges, and cottonwoods. In steeper, headwater streams, with shallow soils, riparian vegetation is often only a single level canopy; however, this canopy is important in stabilizing water temperatures (Roberts, R.C. 1984). Riparian areas are vital as a source of water and are a corridor for wildlife transit through an area. It is estimated that only 2-15% of historic riparian habitat remains in California (RHJV 2004).

A survey of riparian zones along 15.5 miles of Kelsey Creek was conducted in 1985 as a component of the Aggregate Resource Management Plan (Lake County Planning Department 1992). The surveys included detailed descriptions of channel conditions, adjacent land use and riparian plant communities. No surveys of channel conditions and riparian habitat have been carried out since that time.

As the land rises to the south of Big Valley, blue oak woodlands, mixed blue oak, foothill pines, and annual grasslands predominate (annual grassland and hardwood in Plate 11). Some of these grasslands may have been cleared from blue oak woodlands. The grasslands contain an array of introduced grasses and forbs which have replaced native perennial bunch grasses (CalPIF 2000, CDFG 1988). Like valley oaks, the acorns from blue oaks provide a vital seasonal resource to wildlife. In the past, the Big Valley Watershed Council has had a program teaching local children about the value of oak trees and helping the children to propagate and plant oaks.

Statewide, both valley and blue oaks have been identified as showing poor to moderate regeneration resulting in concern for their future viability as a forest type. Young, first year seedlings and old trees are present, but a combination of competition from introduced grasses, fire suppression, and herbivory appears to inhibit seedling survival (CalPIF 2002b). No information on the success of oak regeneration for valley and blue oaks in Lake County was found for this assessment.

At approximately 2,000 feet elevation, chaparral becomes the dominant vegetation in the watershed. Chaparral is brushy habitat that occurs on dry, shallow soils. It contains many fire-adapted plants whose seeds germinate and roots re-sprout following fire. In the chaparral, islands of knobcone pine and McNab cypress also rely on fire for their seeds to germinate (closed-cone pine-cypress in Plate 11).

Scattered areas of oak woodlands occur along higher ridges (hardwoods in Plate 11). The oaks found in the upper watershed, California black oak, interior live oak, Shreve oak, canyon live oak, coast live oak, and tanoak, have not been found to have problems with regeneration. However, some of these species are susceptible to sudden oak death (SOD), caused by the agent, *Phytophthora ramorum*. SOD has not been found in the Kelsey Creek Watershed, and the risk of SOD spread may be low because the watershed is inland from the coastal fog belt where SOD is prevalent. Nevertheless, watershed residents and visitors should avoid introducing potentially contaminated plant material or soil attached to vehicle tires and shoes from infected areas (COMTF 2004). Lake, and other counties where SOD has been found, are under state and federal quarantines regulating transportation of wood products and nursery plants that host SOD.

Conifer habitats in the upper watershed include areas dominated by Douglas fir, areas dominated by ponderosa pine, and mixed conifers and hardwoods. Douglas firs are present in cooler, wetter locations, generally on north and east facing slopes, while ponderosa pines are more prevalent in dry locations, generally on south and east facing slopes. These habitats support a wide diversity of wildlife; however, previous forest management and fire suppression activities reduce structural diversity, and therefore, habitat value of these forests (CalPIF 2002a, CDFG 1988).

Figure 10.1. Conifer forests on Cobb Mountain, May 3, 2008.
Photo by Kevin and Jennifer Ingram.

A more detailed description of wildlife habitats is given in Appendix J. Information for this section and Appendix K comes from the California Department of Forestry and Fire Protection (CalFire) Fire and Resource Assessment Program multi-source land cover data. The land cover data is compiled from various mapping efforts throughout the state, and the information is combined into the California Wildlife Habitat Relationships (CWHR) system of classification (CDFG 1988). Much of the mapping is based on remote sensing, and field verification is needed to confirm the accuracy of the mapped habitats in the Kelsey Creek Watershed.

10.2 Wildlife

The California Wildlife Habitat Relationships System (Version 8.1, 2005) was used to determine potential terrestrial vertebrate species present in the Kelsey Creek Watershed. This database allows the user to input CWHR habitats found in the watershed, and it generated a list of 14 amphibians, 22 reptiles, 231 birds, and 65 animal species potentially present in the Kelsey Creek Watershed during all, or some part, of the year (Appendix K). In the upper watershed environmental studies for potential geothermal developments have developed lists of plant and animal species present in limited areas. A list of these studies is given in Appendix L.

10.3 Sensitive Species

The CWHR system also identifies species status, and 54 threatened, endangered, protected, or sensitive species potentially found in the Kelsey Creek Watershed were identified (Appendix K).

The California Natural Diversity Database (CNDDB) is a natural heritage program to provide information on the location and status of rare and endangered plants, animals, and natural communities, when they have been discovered. The lack of information on sensitive species in a given area does not mean they are not present because the area may not have been surveyed. The CNDDB list of sensitive species that have been observed in and immediately adjacent to the Kelsey Creek Watershed is given in Table 10.1. Only two endangered species, the Lake County stonecrop and Boggs Lake hedge-hyssop, have been found in the area. A CNDDB list of sensitive species found in the entire county is given in Appendix M (CNDDB 2008).

Table 10.1 Rare, threatened, and endangered species that have been observed in and adjacent to the Kelsey Creek Watershed (CNDDB 2006).

Scientific Name	Common Name	Federal Status[1]	California Status[2]	CDFG[3]	CNPS Rank[4]
Amphibians					
Rana boylii	foothill yellow-legged frog	None	None	SC	
Fish					
Lavinia exilicauda chi	Clear Lake hitch	None	None	SC	
Archoplites interruptus	Sacramento perch	None	None	SC	
Invertebrates					
Calasellus californicus					
Plants					
Erigeron angustatus	Greene's narrow-leaved daisy	None	None		1B.2
Layia septentrionalis	Colusa layia	None	None		1B.2
Cryptantha clevelandii var. dissita	serpentine cryptantha	None	None		1B.1
Streptanthus morrisonii	see individual subspecies!	None	None		
Legenere limosa	legenere	None	None		1B.1
Sedella leiocarpa	Lake County stonecrop	Endangered	Endangered		1B.1
Arctostaphylos canescens ssp. sonomensis	Sonoma canescent manzanita	None	None		1B.2
Arctostaphylos manzanita ssp. elegans	Konocti manzanita	None	None		1B.3
Lupinus sericatus	Cobb Mountain lupine	None	None		1B.2
Hesperolinon adenophyllum	glandular western flax	None	None		1B.2
Sidalcea oregana ssp. hydrophila	marsh checkerbloom	None	None		1B.2
Eriogonum nervulosum	Snow Mountain buckwheat	None	None		1B.2
Eriastrum brandegeeae	Brandegee's eriastrum	None	None		1B.2
Navarretia leucocephala ssp. bakeri	Baker's navarretia	None	None		1B.1
Ceanothus confusus	Rincon Ridge ceanothus	None	None		1B.1
Gratiola heterosepala	Boggs Lake hedge-hyssop	None	Endangered		1B.2
Penstemon newberryi var. sonomensis	Sonoma beardtongue	None	None		1B.3

[1] Federal species status.

[2] State of California species status.

[3] California Department of Fish and Game. SC indicates species of special concern.

[4] California Native Plant Society Ranking. 1A presumed extinct in California (CA), 1B rare, threatened, or endangered in CA or elsewhere, 2 rare, threatened, endangered in CA, more common elsewhere, 3 status uncertain, 4 limited distribution, 0.1 seriously threatened in CA, 0.2 fairly threatened in CA, 0.3 not very threatened in CA.

11.0 Aquatic Habitats and Species

The approximate 20 feet high waterfall located 3.3 miles above the mouth of Sweetwater Creek is a natural barrier to upstream movement of all fish species. Therefore, fish habitat and populations in the Kelsey Creek Watershed are discussed for the sections of the watershed above and below the waterfall.

11.1. Upper Kelsey Creek

11.1.1. Aquatic Habitat

Kelsey Creek has been described as "one of the most important trout streams in Lake County" (DFG 1970a). While current information on Kelsey Creek fisheries and stream habitat is not available, it is likely that on a broad scale conditions described in DFG surveys (1958-1974) and the 1985 ARMP survey (Lake County Planning Department 1992) still apply. For localized stream sections it is possible that conditions have changed.

The upper portions of Kelsey Creek and several of its upper tributaries are perennial streams considered excellent brown and rainbow trout habitat. Kelsey Creek was described as having shelter from extensive streamside vegetation, generally good spawning areas for trout, varying pool, run and riffle development, and food present as aquatic insects and their larvae (DFG 1958, 1970a, 1974a). The 1985 ARMP survey described the 5.5 mile section of Kelsey Creek below the creek's intersection with Highway 175 :

> Both fisheries and wildlife values are very high throughout this upper segment. The banks are well vegetated. This is one of the few creek segments supporting montane riparian forest. White Alder (Alnus Rhombifolia) and Bigleaf maple (Acer macrophyllum) replace Cottonwood (Populus fremontii) as the dominant riparian trees in this higher elevation. The creek is perennial throughout this segment. The channel is narrow and contains an abundance of cool, shaded pools and spawning beds. (Lake County Planning Department 1992).

11.1.2. Past and Present Fish Species

Rainbow trout, *Onchorynchus mykiss*, are native to Clear Lake and surrounding tributaries, however they apparently were not present above the falls in Kelsey Creek until they were introduced after the arrival of European settlers (Jordan and Gilbert 1894). The California Department of Fish and Game (DFG) introduced brown trout, *Salmo trutta*, and stocked Kelsey Creek stream with non-native rainbow trout. From 1955-1970, Kelsey Creek was stocked with an average of 6,000 catchable rainbow trout per year; however, the program was discontinued due to lack of public access for fishing. Stocking of both rainbow and brown trout occurred prior to 1955, but specific numbers of fish and their sizes were not available (DFG 1974a). Some of the DFG stocking may have occurred in perennial sections of Kelsey Creek below the falls, as well as in upper Kelsey Creek.

Trout numbers in the creek were generally highest in the middle section (from the falls below Glenbrook to Sweetwater Creek) where it is less accessible for fishing. Suckers were also observed in the upper and middle portions of the watershed (DFG 1974a), and these fish were probably transferred from lower Kelsey Creek by fishermen. Non-native minnows have also been observed in upper Kelsey Creek (Rick Macedo, personal communication).

11.2. Lower Kelsey Creek

11.2.1. Aquatic Habitat

The 1985 ARMP survey found that "Along most of its length, the creek's fish and wildlife values remain high, and valley foothill riparian forest persists" (Lake County Planning Department 1992). Specific descriptions of stream sections from the ARMP are given in Table 11.1 below.

These descriptions generally support improvement from a 1974 survey that found "marginal to poor shelter: streamside willows and alders only shelter the shore" with the exception of the canyon (miles 7.05-8.2 in the above table) (DFG 1974a). Aerial photos (Appendix F) show substantial improvement in riparian vegetation from 1970 to 2005 conditions from approximately mile 8.2 to 10.04.

Elders of the Big Valley Pomo Tribe were surveyed in 2008 on a variety of water-related issues. Responses of two elders describing their memories of stream channel and fishery conditions are given in Appendix N.

Table 11.1 Descriptions of Kelsey Creek stream conditions and habitat from the mouth of the creek, 10 miles upstream (Lake County Planning Department 1992).

Location	Description
Mouth (mile 0) to mile 1.19, near Soda Bay Rd.	"The Creek passes from slough through an area of pools and shaded bed."
Miles 2.34 to 3.76, just below Main St. bridge.	"This area has been heavily mined and has not recovered. The channel in this area has lost its riparian forest and has the wide, braided structure characteristic of mined areas."
Miles 3.76 to 7.05	"While this area was also mined, the thalweg (the lowest portion of the channel) supports a new riparian community along its banks, and a new, apparently stable floodplain has developed between the banks and terrace."
Miles 7.05 to 8.2	"The creek reaches nearly pristine conditions…At mile 8.2 the creek enters a canyon area where increased gradient and cool temperatures make this section of creek both physically and biologically more similar to the headwaters area along upper Kelsey Creek."
Miles 8.2 to 9.27	"A heavily mined area exists in the upstream section between miles 8.2 and 9.27. This mile-long section of creek was reconstructed and replanted as part of a mining project in 1986…Wildlife and fisheries values have increased substantially in this section of the creek over the past four years."
Miles 9.27 to 10.04, the mouth of Sweetwater Creek	"Upstream from the restored mining area… fairly pristine conditions with high fish and wildlife values resume."
Above mile 10.04	"Steep inaccessible terrain not included in the ARMP"

11.2.2. Past and Present Fish Species

While sections of lower Kelsey Creek provide suitable trout habitat, much of it has a lower gradient, less vegetative cover, and warmer water temperatures, making it more suitable for warm water fish species. The lowest portion of Kelsey Creek (from the Main St. Bridge to the mouth) goes dry in the summer, but it is still important fish habitat, in particular for species that use it for spawning in the spring.

There were five native fish species that used Clear Lake tributaries such as Kelsey Creek for spawning. Three of these, the Clear Lake hitch, *Lavinia exilicauda chi*, the Clear Lake splittail, *Pogonichthys ciscoides*, and the Sacramento pikeminnow, *Ptychocheilus grandis*, were large minnow species that contributed to "enormous spring migrations up tributary streams" (Cook, S.F. *et al.* 1966). The hitch still spawn in Kelsey Creek and other tributaries of Clear Lake, and their biology and current status is discussed in detail below. The Clear Lake splittail was found only in Clear Lake and its tributaries. Its population underwent drastic reductions in the early 1940s, and it has not been observed since the 1970s. Earlier drying of Clear Lake tributaries due to diversion of water and groundwater pumping may have contributed to the demise of the splittail. Peak splittail spawning occurred two weeks after that of the hitch, and it had a longer requirement for its young to remain in nursery streams than do hitch (Cook, S.F. *et al.* 1966, Macedo, R. 1994).

The Sacramento pikeminnow was previously called the Sacramento squawfish. Like the Clear Lake splittail, populations of the Sacramento pikeminnow in Clear Lake declined drastically in the early 1940s. The pikeminnow is a fluviatile, or river-adapted species, unlike the Clear Lake hitch and splittail, which have become adapted to lake conditions. DFG surveys noted the presence of pikeminnow (squawfish) in Kelsey Creek up to a large waterfall above the mouth of Sweetwater Creek (DFG 1974a).

The Sacramento sucker, *Catostomus occidentalis*, is a native fish with a similar history to the pikeminnow. Although it was not recorded as part of large spring migrations, it was frequently taken by hook and line from Clear Lake prior to the 1930s, and became rare by 1966. Therefore, a lake population that spawned in tributary streams apparently declined over that time period. Like the pikeminnow, suckers are stream and river adapted. DFG stream surveys of Kelsey Creek (1958-1974) noted the presence of suckers throughout the watershed.

Tributaries of Clear Lake were spawning streams for steelhead (anadramous Rainbow trout) prior to the 1914 construction of a dam across Clear Lake's outlet on Cache Creek. Since that time, steelhead and rainbow trout have been stocked in Kelsey Creek many times over the years. Another anadramous fish, the Pacific Lamprey, *Lampetra tridentatea*, is also listed as having occurred in Clear Lake, but is now extinct there.

Many of the introduced warm water fish species found in Clear Lake can be found in lower portions of Clear Lake tributaries. Fish that have been observed include bullhead catfish, carp, and largemouth bass (Rick Macedo, personal communication).

11.2.3. Clear Lake Hitch

Recovery of the Clear Lake hitch, a subspecies found only in Clear Lake and its tributaries, has become the focus of a local Coordinated Resource Management and Planning (CRMP) group called the Chi Council, which includes Sierra Club members, local landowners, local Tribes, and representatives of government agencies. The hitch is a large minnow that has been designated a species of special concern in California because of decreasing populations and limited geographic distribution (Moyle *et al.* 1995). Their spawning runs were once one of the most impressive natural events in the tributary watersheds of Clear Lake:

> Hitch mass by the thousands and ascend the many streams leading into Clear Lake. The tumultuous splashing in creeks and the appearance of herons, osprey, egrets, and bald eagles in trees overhanging streams signify to the human observer that the hitch is in. Along streambanks, raccoons, mink, otter, and even bears join the birds to feast on hitch as they make their way up swiftly flowing streams (Macedo, R. 1994).

The hitch was also once a staple food for local Native Americans. They were dried and eaten year round and were an important resource for trade with other native people.

There is limited documentation of historic hitch populations. Pre-1900s historical records described streams that were packed solid with fish on some years (Allison G.M. and W. R. McIntire 1949, Rideout, W.L. 1899), and a 1960s study of fish in Clear Lake considered the hitch to be abundant (Cook, S.F. *et al*. 1966). Local residents agree, however, that runs in recent years are much reduced relative to earlier decades, and hitch have disappeared from Schindler and Seigler Canyon Creeks where they once occurred. Since 2004, a local group, the Chi Council, has been carrying out volunteer monitoring of hitch spawning runs. This group has documented annual variability in hitch runs and even a disappearance of spawning runs in Clover and Middle Creeks in 2006 and 2007, with a return in 2008 (Chi Council 2008).

Figure 11.1 Clear Lake hitch will swim in water flowing through pastures and other low-lying areas. *Photo by Greg Dills.*

Numerous factors are believed to contribute to the decline in hitch populations. Many fish species introduced to Clear Lake over the past century feed on hitch juveniles, and channel catfish and large-mouth bass feed on adults (Moyle P.B., 1995). Other introduced species such as the Mississippi Silversides and threadfin shad compete with hitch for food. Wetlands along the shores of Clear Lake are important habitat for juvenile hitch and have declined by 79% from their original extent (Week 1982). Spawning habitat has been reduced because streams dry up earlier than in the past, and because of barriers to hitch migration. The major barriers to hitch migration on Kelsey Creek, the old Quercus Bridge, Kelsey Creek Detention Structure, and Main Street Bridge were described in the diversions and barriers section above. Additional smaller barriers are likely to be present on tributaries to Kelsey Creek, and a survey to identify and prioritize all barriers to hitch migration is an important first step to eliminating these barriers. There are many unknown factors about the hitch, for example their swimming capabilities and requirements for fish passage, the importance of shoreline habitat in juvenile hitch survival, and factors determining the size and success of spawning runs. The Chi Council continues to pursue contacts and funding with government agencies and academic institutions to study the hitch and improve their habitat (Chi Council 2004). Local Tribes began a hitch tagging study in 2009, and they are developing an Adaptive Management Plan that will address migration barriers, high nutrient loads, water use for agriculture and development, and streamflows.

LCWRD staff has begun design on an alternative fish ladder at the major barrier to hitch migration on Kelsey Creek, the Kelseyville Main Street Bridge. This fish ladder would be a ramp built with rocks and boulders across the entire creek below the bridge footing. Project completion will involve additional design work, environmental review, and project construction. Funding from grants or other sources will be needed to complete this approximately $600,000 project.

A more detailed description of the hitch life cycle and the reasons for the decline in hitch populations is given in Appendix O.

11.3 Clear Lake Fisheries

There are 11 native and 19 introduced fish species in Clear Lake, and 3 native species that are now extinct in Clear Lake (Table 11.2). A thorough description of when species were introduced and changes in fish populations is beyond the scope of this assessment. From the discussion in section 11.2.2 and the list of species and their status below, it is clear that the populations of many native fish have declined while some introduced species have thrived.

Table 11.2 Past and present fish species known to have occurred in Clear Lake, California.

Common and Scientific Names	Native (N) or Introduced (I)	Status (A,C,R,E)*
Rainbow trout, *Oncorhynchus mykiss*	N	R
Brown trout, *Salmo trutta*	I	R
Pacific Lamprey, *Lampetra tridentate*	N	E
Goldfish, *Carassius auratus*	I	A
Carp, *Cyprinus carpio*	I	A
Clear Lake hitch, *Lavinia exilicauda chi*	N	R-C
Golden shiner, *Notemigonus crysoleucas*	I	R
Sacramento blackfish, *Orthodon microlepidotus*	N	C
Clear Lake splittail, *Pogonichthys ciscoides*	N	E
Sacramento Pikeminnow, *Ptychocheilus grandis*	N	R
California roach, *Hesperoleucas symmetricus*	N	R
Hardhead, *Mylopharodon conocephalus*	N	E
Fathead minnow, *Pimephales promelas*	I	C
Thicktail chub, *Gila crassicauda*	N	E
Sacramento sucker, *Catostornus occidentalis*	N	C
White catfish, *Ictalurus catus*	I	C
Brown bullhead, *Ictalurus nebulosus*	I	C
Channel catfish, *Ictalurus punctatus*	I	C
Mosquitofish, *Gambusia affinis*	I	C
Threadfin shad, *Dorosoma petenense*	I	R**
Inland silverside, *Menidia beryllina*	I	A
Threespine stickleback, *Gasterosteus aculeatus*	N	R
Sacramento perch, *Archoplites interruptus*	N	R
Green sunfish, *Lepomis cyanellus*	I	R
Bluegill, *Lepomis macrochirus*	I	A
Redear sunfish, *Lepomis microlophus*	I	R-C
Pumpkinseed, *Lepomis gibbosus*	I	R
Largemouth bass, *Micropterus salmoides*	I	A
Smallmouth bass, *Micropterus dolomieui*	I	R
Black crappie, *Pomoxis nigromaculatus*	I	R-C
White crappie, *Pomoxis annularis*	I	R-C
Tule Perch, *Hysterocarpus traski*	N	C
Prickly sculpin, *Cottus asper*	N	A

* Status designations are subjective, based on electrofishing observations, and may not represent a definitive survey of the abundance of each fish species. These status designations have not attempted to place the species population in context relative to historical abundance. Electrofishing stations are typically associated with a variety of littoral, or shoreline habitats, are usually observed at night, and most of the stations have been revisited regularly over the past eight years in the spring and fall. A= Abundant, or present in large numbers at all or nearly all stations that correspond to the species preferred habitat; C=Common or present at most stations; R=Rare, or present at a few stations; E=Extinct, or have not observed the species at any stations.

Source: CDFG 2000. This table was updated in 1995.

**Threadfin shad populations go through boom and bust cycles. At times they are very abundant.

12.0 Invasive Species

Invasive species are a form of "biological pollution", capable of damaging ecosystems just like other forms of pollution. Invasive species are defined as any non-native species "whose introduction does or is likely to cause economic or environmental harm or harm to human, animal, or plant health" (United States 1999). They include plants, animals, and disease-causing microorganisms such as bacteria and fungi, and they occur in all ecosystems from lakes and streams to forests, grasslands, and agricultural areas. Some traits that are common to invasive species include rapid growth and reproduction, and the abilities to spread, adapt to a wide range of conditions, and live off a range of food types (Wikipedia 2008). Invasive species pose a particular threat to sensitive species whose populations are already reduced by habitat loss and degradation.

Once established invasive species may be spread both by human activities and natural causes such as animal movement, wind, or water movement; however, in most cases the original introduction of a non-native species occurred due to human activities.

Identification of which species are invasive is complicated by differing human perspectives. While a non-native species may provide benefits to some people, if its negative effects outweigh the beneficial effects, it is considered invasive. An example is water hyacinth which has been popular in aquatic gardens, but when it escaped to natural areas, it completely covered lakes and rivers, devastating their ecology. As a practical matter, "because invasive species management is difficult and often very expensive, these worst offenders are the most obvious and best targets for policy attention and management" (NISC 2006). Invasive species are also considered to be those not under human control or domestication. Therefore, escaped domestic plants and animals can be considered invasive if they meet the definition of invasive species (NISC 2006).

12.1 Terrestrial Invasive Species

12.1.1 Plants

Invasive species are a continuing problem leading to:

- Reduction of native plant populations, including endangered species.
- Loss of wildlife habitat and food sources.
- Degraded range and timber lands.
- Increased fuel loads.
- Reduced water resources.

A brief summary of the plants considered to be most noxious in Lake County based on the pamphlet 'Invasive Weeds of Lake County' is given in Table 12.1. Internet resources on invasive species are listed in the Appendix D.

Table 12.1. Invasive terrestrial weeds in Lake County.

Name	Description	Economic or Environmental Harm
Arundo/Giant Reed *Arundo donax*	10-20 ft. tall cane-like stems, perennial.	Found in riparian areas; Excludes other vegetation creating monoculture unsuitable for bird and wildlife habitat.
Brooms, Scotch & French *Cytisus scoparius & C. monspessulanus*	5-10 ft. tall shrubs with yellow flowers in late spring.	Replaces native woody and annual species; Prevents tree seedling growth; Increases fuel load.
Medusa Head *Elymus caput-medusae*	Winter annual grass resembling foxtail; 10-12 in. tall.	Replaces desirable rangeland forage plants; High silica content makes it unpalatable to livestock and wildlife.
Milk thistle *Silybum marianum*	6 ft. tall thistle with 2 ft. long dark green leaves, pink flowers in late spring.	Forms dense, impenetrable thickets; Can be poisonous to livestock.
Perennial Pepperweed/White top *Lepidum latifolim*	2-4 ft. tall stalks; white flowers in early June.	Common in riparian areas, roadsides, and fields; Displaces native species and habitat.
Puncture vine/Goats head *Tribulus terrestris*	Annual; forms circular, flat mat; seeds sharp, yellow flowers.	Found in disturbed areas; Seeds that form by late summer puncture bicycle tires, injure feet and hooves.
Tamarisk/ Salt cedar *Tamarisk sp.*	Large, up to 25 ft. tall shrub, pink blooms in late spring.	Grows in stream channels, moist areas; Eliminates native plants through rapid growth and reproduction and accumulation of salt in soil; High water user.
Tree of heaven/Chinese sumac *Ailanthus altissima*	Deciduous tree with large, compound leaves; yellow green flowers become papery seeds.	Extensive, vigorous root system damages roads, sidewalks, buildings; Spreads; Toxin from roots inhibits other plants.
Yellow Starthistle *Centaurea soltitalis*	Annual or biennial weed; up to 3 ft. tall, yellow flowered; spiny seed heads.	Poisonous to horses, mules, and donkeys; Poor forage for cattle; Competitive; Replaces desirable plants.

Source: Lake County Agricultural Commissioner. 2002. Invasive Weeds of Lake County.

Mapping for arundo and tamarisk has been carried out under a grant received by the West Lake RCD and Lake County Department of Public Works. Numerous finds for these two weeds have been made, especially along lower Kelsey Creek (Plate 12). Countywide thus far, approximately one-third of the arundo sites that have been found have been eradicated. Grant funding and efforts to eradicate arundo are on-going.

12.1.2 Animals

The term invasive species has generally been applied to plants, however it is used increasingly for non-native animals associated with increased negative consequences. Examples of invasive mammals include the roof rat (*Rattus rattus*), Norway rat (*R. norvegicus*) and feral house cats (*Felis domesticus*), both of which prey on native birds and small mammals. Feral pigs cause environmental damage by rooting the soil, which causes erosion and promotes invasive/exotic weed establishment, and readily feeding on native wildlife and vegetation. At the same time, feral pigs provide popular hunting activites. The California DFG reported 5,438 were taken in the state in 2005/2006 (Kreith, M. 2007).

The European starling was introduced to the United States in 1890 and first appeared in California in the 1960s. Since then it has become widespread and is known to compete with other birds for nest cavities. Wild turkeys, native to the eastern United States, were introduced to California in the 1970s and have successfully established populations throught the state. A popular game bird, their environmental impacts are unknown at this time, although their voracious appetites are well documented. Brown-headed cowbirds were once found only in the Midwest where they followed bison herds. They have expanded their range to most of North America. Cowbirds are brood parasites, laying their eggs in the nests of other birds, and they can seriously affect reproduction of numerous songbird species.

Bull frogs (*Rana catesbeia)* are native to the eastern United States, and were introduced to California around 1900. Along with invertebrate prey, adult bull frogs prey on other amphibians and even mice, snakes, and birds. They damage native amphibian populations both by preying on them and by competing for food and space (CDFG 2005).

With a $31 billion agriculture industry in California, introduced insect pests pose a significant economic threat. In addition, eradication or control of the pests may require increased pesticide use with the potential for environmental harm. Insect pests newly introduced to California with the potential to damage Lake County crops include two vineyard pests, the glassy-winged sharpshooter and vine mealybug, and the light brown apple moth, which threatens a variety of orchard crops and grapes. Other insect pests that may affect agriculture, landscape, and forest plant species include several fruit fly species, the Japanese beetle, and the Gypsy moth. The Lake County Agriculture Department (LCAD) has trapping programs for these pests

(Section 16.9). Thus far the county appears is free of them with the exception of vine mealybug, which has been found in one vineyard outside the Clear Lake watershed.

12.1.3 Diseases and Parasites

Some diseases and parasites are included in definitions of invasive species (NISC 2006). West Nile virus, transmitted by mosquitoes and causing disease in humans and birds, is considered an invasive species. The Lake County Vector Control District monitors for the presence of West Nile virus and controls mosquito populations in the county. Sudden Oak Death is a disease affecting many oaks in coastal counties. (See Terrestrial Wildlife Habitats chapter.)

12.2 Aquatic Invasive Species

12.2.1 Plants

Many invasive aquatic plants arrived as aquarium (hydrilla and Eurasian watermilfoil) or landscaping plants (water hyacinth, water primrose) (Table 12.2). These plants have the ability to form dense mats, interfering with boating and swimming. When they reach the surface or float on the surface, they provide habitat for mosquito larvae in small protected pools of water in their foliage.

Table 12.2 Invasive aquatic plants in Lake County, California.

Name	Description	Economic or Environmental Harm
Hydrilla *Hydrilla verticillata*	Rooted, submerged plant with branching stems; pointed leaves, reaches up to 36 ft.	Forms dense vegetation mats that interfere with recreation and destroy fish and wildlife habitat; Spreads by fragmentation, seeds, tubers.
Eurasion Watermilfoil *Myriophyllum spicatum*	Rooted, submerged plant with feathery leaves; 3-10 ft. tall or more.	Forms very dense mats; Spreads by fragments; Competetive due to early spring growth.
Water hyacinth *Eichornia crassipes*	Free-floating with rounded, leathery leaves, large purple to violet flowers, few inches to 3 ft. tall.	Rapid growth and reproduction cause rapid extension of free-floating mats; Seeds eaten and transported by water fowl.
Water primrose *Ludwigia peploides* & *L. hexapetala*	Bright yellow flowers and willow-like leaves, creeping on shoreline, floating, or upright.	Forms dense mats of vegetation, primarily along margins of lakes and streams; Spread by seeds and plant fragments; Out-competes tules and other emergent aquatic vegetation.

Source: Lake County Agricultural Commissioner. 2002. Invasive Weeds of Lake County.

Of the plants listed in Table 12.2, hydrilla is considered the most serious invasive plant because of its ability to spread rapidly and form dense mats throughout the water column. It is an A rated pest by CDFA, requiring eradication. In 1994 it was discovered in Clear Lake, and an eradication program was begun the same year. Following three seasons without hydrilla detection in Clear Lake, no herbicides were applied to control hydrilla in 2006 (CDFA, 2006). In 2007-2009; however, additional hydrilla finds were made and control resumed in the areas of the finds. The CDFA Hydrilla Program crews monitor for other invasive and native aquatic submerged plants as part of the program to monitor for hydrilla.

Water primrose is a damaging invasive because of its competition with tules which provide important nesting habitat for grebes. Eurasian watermilfoil is present in Clear Lake, but has not reached damaging populations. A small population of water hyacinth was detected in Clear Lake and was removed.

12.2.2 Animals

Numerous fish species have been introduced to Clear Lake (Table 11.2), and these introductions have reduced native fish populations. Some of the introduced fish such as bass, bluegill, crappie, and catfish prey on juvenile fish, and bass and catfish consume adult fish as well. Other introduced fish such as the silversides and shad are planktivores that compete for food with native fish like the hitch that rely on the same food source. The introduced fish species are not considered invasive because many are considered to have the benefit of improved sport fishing and because elimination of the introduced species is not possible. Management, such as increasing wetlands important for the survival of juvenile fish, may help to insure the success of native fish populations.

Non-native freshwater mussels, such as quagga and zebra mussels, pose a significant threat to Clear Lake. Both of these mussel species reproduce rapidly, covering hard surfaces, clogging water intake pipes, and covering beaches with their small, sharp shells. They are filter feeders capable of consuming a large proportion of the plankton, microscopic floating plants and animals, present in a water body. Because plankton are the base of the food chain for aquatic ecosystems, this can severely affect the entire ecosystem. Both species are found throughout the eastern United States, and both are now found in several water bodies in California (USGS 2008). To prevent their introduction into Clear Lake water bodies, the Lake County Board of Supervisors adopted an urgency ordinance on March 25, 2008 requiring inspection of all vessels entering Clear Lake (Lake County 2008), and on May 20, 2008 the Board of Supervisors adopted Ordinance No. 2866 formalizing the program.

The New Zealand mud snail is found in scattered locations around California. It prefers moving water and is found in streams, rivers, and lakes. It may have the potential to out-compete native invertebrates such as mayflies, caddisflies, and chironomids that are important food sources for fish (CDFG 2008). To date it has not been found in Lake County.

13.0 Fire and Fuel Load Management

With California's dry summers, fire is a natural occurrence, and many plants and animals are adapted to fire. The severity of wildfires depends on the dryness of vegetation and ground cover, weather conditions such as wind speed and temperature, and the amount of fuel available. The severity and extent of fires determines the damage to wildlife and plant communities as well as the potential erosion, sedimentation, and changes in hydrology following a fire. Wildfire damage to people, their communities, and livelihoods depends on where people choose to live and work and how they manage surrounding fire-prone areas. Prescribed or controlled burning and other methods of fuel load reduction help to reduce the potential for severe wildfires.

13.1. Fire Cycles

> "Where there is fire, there is a fire cycle. The fire cycle is the number of years, on average, that a fire historically moved through the area. It is also called the fire return interval. Every ecosystem has a fire cycle. Even the coastal areas have fire cycles, though they are very long—perhaps 300 years or more. But in very hot, dry areas; fire cycles might be as short as every 1–7 years" (Nunamaker, C. 2002).

The quote above refers to natural fire cycles, which are determined by factors such as vegetation, dry weather conditions, and the frequency of thunderstorms. For the California North Coast, a ranking of the length of natural fire cycles, which includes fire ignition by Native Americans, states "In general, the most frequent fire occurred in grasslands and oak woodlands, with decreasing fire frequencies in chaparral, mixed evergreen, and montane mixed conifer" (Stuart, J.D. and S.L. Stephens 2006).

In many areas of California, there is evidence that Native Americans deliberately set fires to manage local ecosystems. This included using fire in grasslands and oak woodlands (Ortiz, B.R. 2006, Anderson, K. 1993, Stuart, J.D. and S.L. Stephens 2006) and in chaparral ecosystems of California's Central and South Coast (Keeley, J.E. 2002). Writing specifically about the Clear Lake area, Simoons (1952) notes that "with an abundant fish and fowl resource there may have been less incentive for burning than in areas where hunting furnished a larger part of the food." However, it is likely that Native Americans contributed to the local fire regime, if only due to accidental fires.

Settlers in the Clear Lake region used fire to thin out brush and encourage grass growth for livestock, to increase deer feed, and to prevent fuel accumulation in coniferous forests (Simoons F.J. 1952). Sheepmen were notorious for setting large fires, and loggers used fire to clear recently logged land, with the potential for fire escape to unlogged forests (Stuart, J.D. and S.L. Stephens 2006).

In the early twentieth century, a policy of fire exclusion was adopted by the United States Forest Service. In ecosystems that previously had short fire cycles this policy had unintended consequences. Drier forests of the western United States, which include ponderosa pine or mixed pine and Douglas fir forests, had natural fire cycles of 30 years or less. Fires in these ecosystems help to reduce fuel build up and maintain open stands of large trees. The consequence of fire suppression in these forests is the potential for high severity crown fires that can wipe out entire forests (Agee, J.K. 2007). In areas of local shrubland, it is likely that fire suppression has led to replacement of grass understory/oak woodlands with chaparral (J. Tunnell, personal communication).

Fire history in the Kelsey Creek Watershed is shown in Plate 13. A major fire, called the Widow Creek Fire, burned much of the brush land in the upper watershed in 1962. No large fires have occurred since that time; therefore, fuel loads have been increasing for 48 years.

13.2. Fire and Natural Communities

There are many examples of plants in the Kelsey Creek Watershed that are fire-adapted. The importance of fire in chaparral is recognized in most definitions of the plant community. “Chaparral is a shrubland or heathland plant community found primarily in California, that is shaped by a Mediterranean climate (mild, wet winters and hot, dry summers) and wildfire” (Wikipedia 2007). Many chaparral plants have seeds that require intense heat to germinate and/or fire-resistant roots that enable them to re-sprout quickly following a fire (CDFFP 2001). Native oak trees can withstand burning of much of their foliage. Even when severe fires kill the tops of oak trees, many will sprout from their base the following year (McCreary, D.D. 2004). Ponderosa pine is adapted to high frequency, low intensity fires that create open stands with little understory. At 5-6 years of age, ponderosa pines shed lower limbs and develop thick bark and deep roots that enable them to withstand low intensity fires. Douglas fir is also considered better able to withstand fire than most conifers (NIFC, 2008).

Most animals are able to avoid fires of moderate severity. Lizards, snakes, and reptiles survive by going below ground during a fire. Birds can fly from a fire, although their young are vulnerable to fires during the nesting season. Larger mammals such as deer, coyotes, raccoons, and bears must escape by running away, and fast moving fires can be dangerous for them. Following an experimental fire on California's Central Coast that burned 50% of 500 acres of blue oak-coast live oak woodland, researchers found "no substantial or long-term negative impacts to over 150 species of birds, small mammals, amphibians, and reptiles" (McCreary, D.D. 2004).

Fire suppression in coniferous forests has been connected to declines in some species of birds.

> "Fire suppression has been a forest management technique that has been to the detriment of the forests as it has resulted in decreased structural diversity, often producing a dense homogeneous forest with closed canopy and little shrub cover… Fires also create suitable habitat for primary and secondary cavity nesters through the killing of trees or limbs" (CalPIF 2002).

13.3. Fire Effects on Erosion and Hydrology

Undisturbed soils in natural ecosystems are usually well covered with a combination of vegetation such as grasses and herbaceous plants, duff (plant residues), and woody debris. With greater fire severity, more of the soil cover is removed, which exposes the mineral layer to raindrop impact and overland flow. When vegetation is removed, dry ravel and debris movement is more likely, especially on steep slopes. Fire can also increase water repellency of soil, which increases surface water run-off. Creation of water repellency is unlikely under prescribed fire conditions when initial soil conditions are usually wetter (Robichaud, P.R. 2000).

At a larger scale, the amount of erosion that occurs and the delivery of sediment to water courses depends on numerous factors:

- The steepness of the area that is burned.
- The severity, extent and spatial variability of the fire.
- The presence of highly disturbed areas such as skid trails for logging.
- The severity of post-fire rainfall.

Even the fire suppression response, for example using bulldozers to create fire lines, contributes to erosion. Although such areas are frequently rehabilitated prior to rainfall, they are still likely to have higher than pre-fire levels of erosion (Robichaud, P.R. 2000, USDAFS 2005).

Following a wildfire, both water quality and hydrology are likely to be affected. Increased sediment in streams may smother aquatic invertebrates and cover gravels needed for fish spawning. Drinking water purveyors may experience higher water treatment costs. In January 1997, treatment plants in Lakeport, Nice and Lucerne were unable to adequately treat water due to high turbidity from the Forks Fire which burned approximately 30% of the Middle Creek watershed in 1996 (USDAFS 1999).

Chemical changes in streams following fire include changes in acidity levels or increased levels of nitrogen compounds. Sediment is a major source of phosphorus to surface waters, and the combination of increased nitrogen and phosphorus may lead to eutrophication. Reduced stream cover can cause warmer water temperatures, which can deplete dissolved oxygen (USDAFS 2005).

Water yield, the amount of water coming from a given watershed, may increase following a fire because of reduced plant water use when vegetation is removed. Increased surface run-off following fires will also change the timing of streamflows, causing flood peaks to arrive more rapidly and reach higher levels. The higher streamflows have the potential to move greater amounts of bedload and suspended sediment. Recovery to pre-fire streamflows may take from several years to decades (Robichaud, P.R. 2000).

13.4. Fire Management

Plate 14 shows fire hazard in the Kelsey Creek Watershed. The forests of the upper Kelsey Creek Watershed fit the definition of fire-adapted forests. Prior to significant efforts to prevent wildfire, these forests may have experienced more frequent but low intensity fires that cleared the understory, but left larger trees intact.

Forest managers today recognize the need to manage these forests to prevent fuel build up. "The principles of firesafe forests are clear:… reduce surface fuels, reduce ladder fuels (those fuels that bridge the gap between surface fuels and overstory canopy fuels), keep the large trees, and reduce crown density" (Agee, J.K. 2007). Removing or compacting surface fuels reduces the surface fire flame height, and treatments to do so include prescribed burning, pile burning, chipping or mastication of vegetation, and use of goats to consume vegetation. Where dense forests have grown up, tree thinning is necessary, and leaving large trees that are more resistant to fire is important (Agee, J.K. 2007). The goal of fire management in fire-adapted forests is not elimination of fire, but limiting fires to low intensity surface fire rather than stand-replacing crown fires.

Fire management objectives are different in the chaparral and closed-cone pine areas of the middle Kelsey Creek Watershed. In these vegetation types, wildfires burn as crown fires, removing most of the vegetation. Management to introduce a patchwork of vegetation age and fuel load can reduce the intensity and spread of wildfires when they occur (Minnich, R.A. and E. Franco-Vizcaino, 1999).

The most recent major fire in the Kelsey Creek Watershed was the 1962 Widow Creek Fire which burned over 10,000 acres, primarily in steep terrain in the upper watershed (Plate 13). Chaparral in the area is mature decadent brush with a heavy dead fuel component. Most skeletal trees from the fire have fallen; however, trees that survived have residual damage resulting in defect and rot. These defects create habitat for cavity nesting birds and den dwelling animals; however, the dead wood also increases the susceptbility of trees to fire. Several large landowners have taken the initiative to conduct prescribed fires to reduce fuel loading; however, their efforts have been "a drop in the bucket" compared to the large scale fuel load (James Wright, personal communication).

The South Lake Fire Safe Council (SLFSC) has been creating fire breaks adjacent to subdivisions in the Cobb area in order to create defensible space in the same area as where the Widow Creek fire was eventually controlled. To allow safe escape from fire and defensible space for fire crews, they are planning to create a fire break along Bottle Rock Road.

Lake County is located within the Sonoma-Lake-Napa unit of the California Department of Forestry and Fire Protection (CAL FIRE). This unit also includes Yolo, Colusa, and Solano Counties, making it the largest CAL FIRE unit in the state. The CAL FIRE goal for this unit

> "is to create not just a heightened awareness of wildfire, but a "fire safe" environment where citizens can continue to live, work, and recreate in the areas that are prone to wildfire; that is, most of the wildland areas of California. To ensure this, the Plan sets out to educate the citizenry to the hazards and risk of wildfire and to engage them in the development of appropriate actions to minimize the negative impacts resulting from wildfire…
>
> In the near-term, public outreach programs and fuel reduction projects will be implemented, many using grant funds. But in the long-term, these programs will become institutionalized, a feature of "living with wildfire." Community-wide fuel management projects will be integrated into aspects of community well being on the same order of priority as community water supply, waste collection systems, flood and erosion control, and neighborhood beautification. Catastrophic wildfire losses will become as rare, or nonexistent, as catastrophic fires in schools, hospitals, high-rises, or any other category of occupancy that has had its' fire risk mitigated aggressively over the years through built-in fire protection measures" (CDFFP 2005).

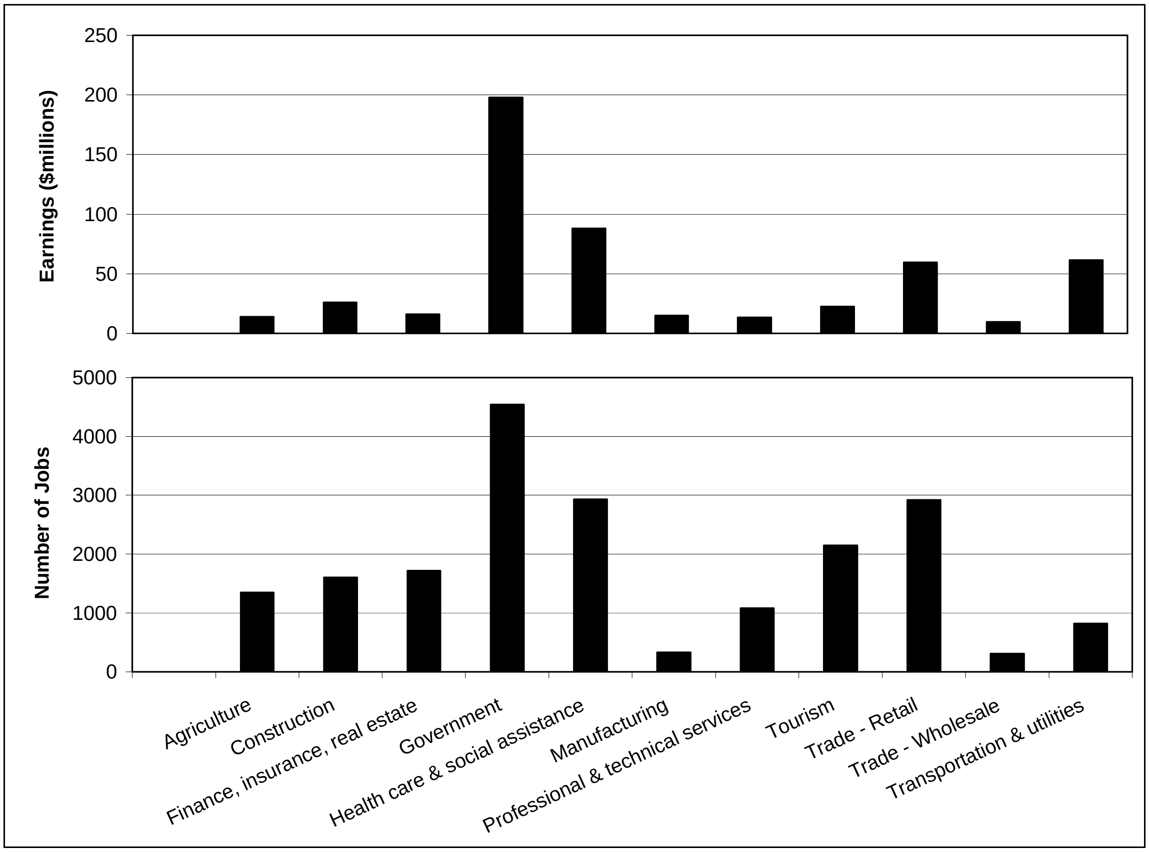
13.5. Wildland-Urban Interface

Increasing numbers of people have moved into fire prone areas of California, termed the wildland-urban interface. Fire hazard is very high throughout most of the upper Kelsey Creek Watershed (Plate 14). Firefighters are better able to protect buildings in areas of more concentrated development, such as subdivisions, than buildings that are scattered more widely in the fire hazard zone. This is because they can better justify concentrating resources in these areas, and property owners can cooperate to set up effective fire breaks in and around these areas. There are many information sources on fire safety for homeowners in the wildland-urban interface (Appendix D). Clearing a defensible space free of highly flammable material around the home is required by California law. Defensible space refers to the area directly around your home (including the home itself) where heat, flames, and embers can ignite the home. As mentioned above, firefighters may not be there to protect your home. The term "Defensible" infers that there will be someone defending your home. A more useful concept is that of "Survivable Space" which means preparing your home to stand on its own without help from firefighters. Other ways to protect your home include using less-flammable building materials and creating easy access for firefighters (Anonymous 2007).

14.0 Social and Economic Setting

There are two population centers in the Kelsey Creek Watershed, the town of Kelseyville and the Cobb Mountain area (Plate 15). Kelseyville, located in Big Valley, had a population of approximately 3,300 based on the 2000 census. It is the largest community in Big Valley, and Big Valley has long been the largest agricultural area in Lake County. For the Kelseyville Area Plan, comprising Big Valley and uplands to the west, the Lake County Community Development Department states that "agriculture is the dominant industry…providing farm labor employment and secondary employment" (LCCDD 1995). The population in the Cobb Mountain area within the Kelsey Creek Watershed was approximately 1,900 in 2000. The mountain and forest environment of the area around Cobb provides attractive residential, resort, and recreation opportunities as well as potential for additional geothermal development (LCPD 1989).

The largest sources of employment in Lake County for both the number of jobs and earnings are government, health care and social assistance, and retail trade (Figure 13.1). Per capita income in Lake County in 2006 was $28,993 compared to $39,626 for California as a whole (BEA, USDC 2008). Because Lake County's median income is below the state median local agencies and organizations are able to claim "disadvantaged community" status in many grant applications.



Source: U.S. Department of Commerce, Bureau of Economic Analysis

Figure 13.1 Employment and earnings for the principal industries in Lake County, 2004.

Lake County's population is projected to grow approximately 15% each decade from 58,000 in 2000 to 107,000 in 2050 (State of California, Department of Finance 2007).

15.0 Land Use

Land use in the Kelsey Creek Watershed, based on Lake County General Plan land use designations, is shown in Plate 16. The area of each land use category is shown below in Table 15.1, and they are discussed in following sections.

Table 15.1 Area of General Plan land use categories in the Kelseyville watershed.

Land use category	Acres
Public lands	4,761
Resource conservation, private	1,393
Rural lands	18,336
Agriculture	5,625
Low density residential*	3,391
High density residential**	920
Light commercial***	243
Heavy commercial/ industrial****	163

*Includes rural residential and suburban residential reserve categories (less than 1 dwelling per acre).
**Includes suburban residential, low, medium, and high density residential, and urban residential (one or more dwellings per acre.
***Includes resort, local, and community commercial.
****Includes service commercial, mixed light/heavy commercial, industrial/heavy commercial, industrial, and resource industrial.

15.1. Residential

Areas designated for high density residential use (1-20 residences per acre) are located in Kelseyville and the Cobb area, and low density residential areas (less than 1 residence per acre) are generally found adjacent and outlying to the high density residential areas.

Because of the high proportion of impervious surfaces in residential areas, surface run-off during storms increases, while recharge to groundwater and to more gradual stream water delivery is reduced. Developed areas create concentrated water flows in ditches, culverts and channelized streambeds that can lead to accelerated erosion. In addition, a variety of pollutants including waste oil, herbicides, pesticides, animal wastes, soaps, and detergents may be flushed via storm drains and surface run-off to streams.

15.2 Rural

In the steep topography of the upper Kelsey Creek Watershed, population density is low. Most of the land is unsuitable for agriculture and timber production. A large proportion of this area is designated as rural lands with the purpose of the designation “to allow rural development in areas that have limited agricultural potential and remain for the most part in their natural state.” While populations may be low in these areas, roads and activities such as construction and livestock grazing may increase soil erosion and sediment loads to streams.

15.3 Agriculture

A large proportion of the level land in Big Valley as well as sloping vineyard lands to the south of Kelseyville are designated agriculture with a minimum lot size of 40 acres.

Agricultural practices such as plowing and disking loosen soil, creating the potential for soil erosion on sloping ground. Management practices of the two crops commonly grown on sloping ground in Lake County, walnuts and winegrapes, are discussed in Section 17.1 Another potential water quality risk from agriculture is from the improper use of pesticides and fertilizer. Although the source has not been identified, nitrate levels in groundwater have increased in some areas of Big Valley. Pesticides have not been detected in Lake County wells, and limited stream studies detected only one pesticide which is still below regulatory levels (Sections 8.2, 8.1.3).

Livestock production has the potential to harm water quality due to fecal contamination of waters and due to hillslope and stream channel degradation from poor management practices (Section 7.3). *E. coli* contamination in McGaugh slough was detected; however, the source (livestock, human, wildlife, or waterfowl) is unknown (Section 8.2).

15.4 Commercial and Industrial

The light commercial land use designation includes resorts and businesses to meet local commercial, retail, and service needs such as general merchandise stores, hardware stores, restaurants, professional offices, and gasoline service stations. These areas are generally found near the communities of Kelseyville and Cobb.

Heavy commercial and industrial land use designations include activities such as automotive or heavy equipment sales and services, construction sales and services, and manufacturing and natural resource processing activities. Areas with this designation are located along Kelsey Creek to the north of Kelseyville.

15.5 Public and Resource Conservation

There are 4,761 acres of publicly owned land in the watershed (Table 15.1), and these include state and county parks, land owned by public utilities, Boggs Mountain Demonstration State Forest, and substantial state and federally owned acreage in the chaparral dominated upper watershed. Many of the state and federally owned lands in the upper watershed are designated resource conservation. "The purpose of this land use category is to assure the maintenance or sustained production of natural resources within the county." The category can include public and private areas of "significant plant or animal habitats; forest lands in Timberland Preserve Zones; agricultural lands within the Williamson Act; grazing; watersheds including waterways and wetlands; outdoor parks and recreation; retreats; mineral deposits and mining areas which require special attention because of hazardous or special conditions; publicly-owned land; (e.g. U.S. Forest Service, BLM land, State, and County); and open space activities" (LCCDD 2008).

Private lands that are designated resource conservation in the Kelsey Creek Watershed are frequently adjacent to the public lands with this designation.

15.6 Geothermal Resources

There is one geothermal power plant in the Kelsey Creek Watershed, the Bottlerock Power Plant, located off of Bottle Rock Road near Alder Creek. DWR operated the plant until 1990, when it closed the plant. In December 2006, a private company, Bottle Rock Power, LLC, received approval from the California Energy Commission to start operating the plant again.

There are numerous active geothermal wells serving the Bottle Rock Power Plant and other power plants, and geothermal exploration continues in the upper watershed (Ron Yoder, personal communication). Watershed residents have raised concerns about potential impacts of geothermal power plant operation. At a November 20, 2008 meeting of Bottle Rock Power Corporation representatives, Lake County officials and neighbors of the power plant, neighbors expressed concerns about dumping of mud from sumps used to catch toxic chemicals from geothermal drilling on a meadow, delayed clean up of a diesel fuel spill, and noise caused by drilling (LCRB 2008). As discussed in section 8.1.1, a DWR station described as "Bottle Rock Power Plant" had many more exceedances of water quality standards during the period from 1978-1987 than did other stream water samples. Other potential impacts on the watershed due to geothermal energy development include construction and post-construction erosion and sedimentation and wastewater leaks.

15.7 Recreation

There are several public parks in the Kelsey Creek Watershed. Clear Lake State Park, located at the mouth of Kelsey Creek on Clear Lake, offers boating, swimming, fishing, camping, nature trails, and a visitor center with displays on the area's natural and cultural history. Along the lake to the west, the county-owned Lakeside park offers fishing, lake swimming, picnic area, horseshoe pits, softball fields, and a boat launch. In the town of Kelseyville, the county-owned Kelseyville Park offers a playground, picnic area, and basketball courts.

At Boggs Mountain Demonstration State Forest, located near Cobb at the upper end of the watershed, recreational opportunities include camping, hiking, single-track mountain biking, driving, equestrian activities, picnicking, target shooting, and hunting. State foresters have found that the forest is used primarily as a local park with day use comprising four times as many visitor-days as overnight camping (CDFFP 2008).

15.8 Native American Lands and Resource Use

Today native people in Lake County live on several parcels of land called 'rancherias' where they have their own local governments. The Big Valley Rancheria, home to the people who inhabited Big Valley and nearby watersheds at the time of European contact, is located on the shores of Clear Lake east of Lakeport.

Local native people make use of a wide variety of plants and animals from the natural environment and are therefore concerned about potential contamination of these resources as well as conservation and restoration of natural habitats. A list of items that are eaten, made into medicines and consumed, or used in ceremonies by the members of Big Valley Band of Pomo Indians is given in Table 15.2.

Table 15.2 Staple plants and animals used by members of the Big Valley Tribe.

Tules	Snails	Blackfish
Cattails	Otters	Perch
Willows	Herons	Trout
Dogwood	Loons	Bluegill
Blackberries	Seagulls	Catfish
Lake clams	Swans	Hitch
Crayfish	Geese	Salmon
Turtles	Grebes	Suckers
Frogs	American coots	

Source: (Ryan S. 2004)

16.0 Current Watershed Management

16.1 Soil Conservation

The Lake County Grading Ordinance (LCCCD 2006) establishes standards for grading and erosion control plans based on project size and soil erosion hazard. The Lake County Community Development Department (CDD) is responsible for enforcing compliance with the ordinance. The Natural Resources Conservation Service (NRCS) is a branch of the United States Department of Agriculture with an office in Lakeport. They provide technical assistance on conservation of soil, water, and other natural resources and have programs for cost-sharing on selected conservation measures.

16.2 Water Quality Protection

Lake County Department of Environmental Health administers regulatory programs that include components designed to protect drinking water quality. These include permits, inspection, and enforcement for water well installation, small public drinking water systems (having 5 to 14 connections and serving fewer than 25 people daily over 60 days of the year), on-site septic sewer systems, underground storage tanks, hazardous material disposal, and solid waste facilities.

Regulation of large public drinking water systems is by the California Department of Public Health. The California Drinking Water Source Assessment and Protection Program requires large public drinking water systems to complete a drinking water source assessment that includes an inventory of possible contaminating activities and a vulnerability ranking to potential contamination (CDHS 1999).

Wastewater discharges from wastewater treatment plants are regulated by the CVRWQCB through Waste Discharge Requirement (WDR) permits. Only discharges to land or for underground injection at the Geysers are allowed, and WDR permits specify the conditions for the discharges. The CVRWQCB issues cease and desist orders to enforce improvements related to spills.

The Lake County Clean Water Program is charged with controlling pollution from urban and other storm drains. To comply with federal mandates for storm water pollution prevention, the CDD manages this program in cooperation with the cities of Lakeport and Clearlake. The CVRWQCB oversees compliance with this program.

The Sacramento Valley Water Quality Coalition monitors stream water quality and promotes agricultural best management practices locally and throughout the Sacramento River watershed to comply with CVRWQCB requirements to reduce non-point source pollution from irrigated agriculture.

Clear Lake is impaired for both nutrients and mercury under Section 303(d) of the Federal Clean Water Act. This required the CVRWQCB to work with the county and other entities to develop the pollution control plans, "total maximum daily loads" (TMDLs) for these contaminants. A monitoring and implementation plan for both the Clear Lake Mercury and Nutrient TMDLs was submitted in October 2008 by the Clear Lake TMDL Stakeholder Committee (CLTSC), comprised of government agencies involved with land and resource management in the area such as the County of Lake, Bureau of Land Management and United States Forest Service; the Bradley Mining Company (owner of the Sulphur Bank Mine) in the case of the mercury TMDL; and the Lake County Irrigated Lands Watershed group in the case of the nutrient TMDL. The CLTSC goals are:

A. Control: Combine resources to achieve required mercury and nutrient load reductions and to eliminate the impairment of the beneficial uses of Clear Lake.

B. Information Exchange: Share information regarding best management practices, monitoring data and methods.

C. Cooperation:

1. Develop and implement a Plan to reduce the input of mercury and reduce the mercury concentrations in the lake sediments.
2. Develop and implement a Plan to collect the information needed to determine what factors are important in controlling nuisance algae blooms and to recommend what control strategy should be implemented (CLTSC 2008).

An update of the Lake County General Plan and an accompanying Environmental Impact Report were approved in September 2008 (LCCDD 2008). The General Plan recognizes water quality issues and regulatory requirements with the goal of protecting surface and groundwater quality. Implementation will include a review process of proposed developments to evaluate potential contaminants and verify compliance with regulatory requirements such as the National Pollutant Discharge Elimination System (NPDES), stormwater and TMDL programs. The county will monitor and work with industries that may discharge pollutants to surface waters to ensure compliance with current regulations and reduce wastewater discharges. Through the Grading and Stormwater Ordinances, the county will "ensure that erosion control measures are utilized during construction and post construction." The county will "attempt to inventory watersheds that drain into Clear Lake and identify those which carry high levels of pollutants and those that have high sediment yield" in order to prioritize them for restoration and management (LCCDD 2008).

16.3 Streambed, Lake and Wetland Alterations

Activities in streams, lakes, and wetlands such as debris removal, restoration projects, or stabilization structures may require permits and environmental review from a variety of agencies. A first step is often to contact the DFG, which requires notification for any activity that will:

- "Substantially divert or obstruct the natural flow of any river, stream or lake,
- Substantially change or use any material from the bed, channel, or bank of, any river, stream, or lake; or
- Deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake.

The notification requirement applies to any work undertaken in or near a river, stream, or lake that flows at least intermittently through a bed or channel. This includes ephemeral streams, desert washes, and watercourses with a subsurface flow. It may also apply to work undertaken within the flood plain of a body of water" (DFG 2008).

If DFG finds that "the activity may substantially adversely affect fish and wildlife resources" then a Lake or Streambed Alteration Agreement is necessary as required in Section 1602 of the Fish and Game Code.

Placement of structures or dredged or fill materials in waters of the United States[10] requires a Section 404 permit from the United States Army Corps of Engineers (USACE) and Section 401 Water Quality Certification from the CVRWQCB. In addition, the state of California requires a permit for discharge into "isolated" waterbodies (EPA 2007, SWRCB 2008).

16.4 Water Infrastructure and Supply

The Big Valley Groundwater Management Plan (1999) and the Lake County Groundwater Management Plan (2006) provide guidance on managing groundwater resources. Objectives of the Lake County Groundwater Management Plan include maintenance of a sustainable high quality water supply for agricultural, environmental, and urban uses, facilitation of projects to replenish groundwater, and improved understanding of groundwater resources.

The Lake County General Plan states several goals with regard to ensuring water availability (LCCDD 2008). Goal WR-3 is "to provide a sustainable, affordable, long-term supply of water resources to meet existing and future domestic, agricultural, industrial, environmental, and recreational needs within the county, so as to maintain sustainability between new development and available water supplies." Implementation measures include designating and managing groundwater recharge areas, managing groundwater resources to ensure sustained yields, working with public agency water providers and local stakeholders to develop groundwater management partnerships, identifying critical water resource areas, and participation in local, state, and regional water resource planning efforts.

The 2008 General Plan also considers water supply in the Public Facilities and Services Chapter. Goal PFS-2 is "to ensure the provision of an affordable, sustainable, reliable, safe, and adequate water supply with distribution and storage facilities to meet the existing and future needs in the county" (LCCDD 2008).

16.5 Flood Management

The Lake County Water Resources Division in the Lake County Department of Public Works is responsible for flood management and updates the Floodplain Management Plan necessary for compliance with the National Flood Insurance Program. Lake County participates in the NFIP which was established in 1968 to provide flood insurance to property owners in return for

[10] Waters of the United States includes "All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including…tributaries of all waters mentioned above" (SRWP 2008).

community floodplain management regulations to reduce future flood damage potential. Lake County has a qualifying Floodplain Management Plan, and therefore Lake County residents can purchase flood insurance under the NFIP (Lake County 2000, FEMA 2002).

Reducing flood hazard is addressed under the 2008 Lake County General Plan Goal HS-6 "to minimize the possibility of the loss of life, injury, or damage to property as a result of flood hazards." In 1% flood chance zones, General Plan policies allow passive recreational activities such as hiking and horseback riding, prohibit the development of critical facilities, and require other developments to minimize flood risk to structures and infrastructure (LCCDD 2008).

Lake County Flood Control Zone 5, covering the area of Big Valley, is funded by a percentage of property taxes. Zone 5 was formed in 1964 to fund operation and maintenance of the Kelsey Creek Water Supply Project (Pomo Dam). The Project was not constructed, and instead Zone 5 funds maintenance and operation of the Kelsey Creek Detention Structure and implementation of the Big Valley Groundwater Management Plan adopted by the Board of Directors in 1999. Due to a loss of DWR funding, the failure of property tax funding to keep up with inflation, and rejection of a benefit assessment by property owners in 1995, Zone 5 could exhaust all reserves by 2015.

Maintaining clear stream channels helps to maintain flow capacity and reduce flood potential. The Lake County Sheriff's Office of Emergency Services website urges property owners to "Remove debris, such as trash, loose branches, and vegetation growing in the stream channel" (LCS 2008). At the same time, stream channel alterations may require approval by agencies such as the DFG, USACE, and CDD (Section 16.3).

16.6 Wildlife and Habitat Protection

The state DFG enforces laws protecting wildlife and their habitats. They issue hunting permits and arrest poachers and polluters. The United States Fish and Wildlife Service (USFWS) administer the Endangered Species Act to protect species and the ecosystems on which they depend. They carry out the scientific studies and list species as "threatened" or "endangered". Once species are listed as endangered, trafficking in the species is prohibited, and critical habitat for the species is protected. The USFWS also has a Division of Migratory Bird Management to conserve migratory birds and their habitats.

The California DFG is the lead agency for fisheries and wildlife management in the state. A description of the agency's role from their website reads:

> "The Department of Fish and Game maintains native fish, wildlife, plant species and natural communities for their

> intrinsic and ecological value and their benefits to people. This includes habitat protection and maintenance in a sufficient amount and quality to ensure the survival of all species and natural communities. The department is also responsible for the diversified use of fish and wildlife including recreational, commercial, scientific and educational uses.
>
> The California Fish & Game Commission adopts fishing and hunting regulations and guidelines for determining whether species have California endangered or threatened status. With respect to non-game species, the DFG manages species of special concern to achieve conservation and recovery before they require California Endangered Species Act listing."

The Lake County General Plan goal with respect to wildlife is "to preserve and protect environmentally sensitive significant habitats, enhance biodiversity, and promote healthy ecosystems throughout the county" (LCCDD 2008).

16.7 Fisheries and Aquatic Habitat Protection

As stated above the California DFG enforces fishing regulations. They also enforce environmental laws with regard to streambed alterations and potential pollution of waterways due to spills and other illegal discharges.

The DFG 2000 Clear Lake Fishery Management Plan has the objectives "to maintain and enhance 1) fishery resources and the habitats upon which they depend, and 2) provide and where possible, improve fishing opportunities." The DFG issues permits for bass fishing tournaments and commercial fishing on Clear Lake and enforces compliance with these permits. DFG also regulates sport fishing through the issuance of licenses and enforcement of fishing regulations (CDFG 2008b).

A local CRMP group, the Chi Council, is dedicated to watershed and lake management to improve populations of the Clear Lake hitch. Members include representatives of conservation groups, local Tribes, local, state, and federal resource agencies, and concerned citizens. The council organizes volunteer monitoring of spawning runs, encourages scientific research on the hitch, gathers information about the hitch and their uses by native peoples, and sponsors habitat restoration. Local Tribes also have programs to monitor hitch spawning runs and stream conditions.

16.8 Integrated Regional Water Management Plan

The IRWMP is an important planning effort related to numerous aspects of watershed management including both surface and groundwater supplies. The proposed planning area for the IRWMP that will encompass the Clear Lake Watershed is comprised of the Cache and Putah Creek Watersheds as well as most of the remaining area of Yolo County. The tentative name for the region is the Westside Region. Participating governments/agencies are; Lake, Napa, Yolo, and Colusa Counties and the Solano Water Agency.

The IRWMP will promote a regional and integrated approach to water management and will foster coordination, collaboration, and communication among agencies and organizations responsible for water-related issues. The plan will cover providing water supply reliability, water recycling, water conservation, water quality improvement, stormwater capture and management, flood management, recreation and access, wetlands enhancement and creation, and environmental and habitat protection and improvement. The IRWMP is intended to provide a comprehensive approach to addressing water supplies as a component of the California Water Plan.

Stakeholder meetings for the IRWMP involving Lake County residents, agencies, and organizations began in May 2007. The meetings have gathered input on Lake County priorities, goals, and objectives for the IRWMP. Currently meetings are being held among the cooperating agencies. Lake County is in the process of finalizing goals and objectives (by the end of 2009) to be included in the IRWMP. By the first quarter of 2010, the Lake County contribution for a planning grant application will be completed. The goal for completion of the IRWMP is the end of 2012.

16.9 Prevention, Eradication and Control of Invasive Species

The US Fish and Wildlife Service has numerous mandates for prevention and control of invasive species. Under the Lacey Act, it regulates the " importation and transport of species, including offspring and eggs, determined to be injurious to the health and welfare of humans, the interests of agriculture, horticulture, or forestry, and the welfare and survival of wildlife resources of the U.S. Wild mammals, wild birds, fish, mollusks, crustaceans, amphibians, and reptiles are the only organisms that can be added to the injurious wildlife list (USFWS 2008)." The National Invasive Species Council is a council of 13 federal departments that deal with invasive species. It was created in 1999 by Executive Order 13112 "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause" (USDA 2008).

In California, CDFA is charged with prevention of importation of pests and diseases and control of pests within the state. CDFA works in cooperation with the state DFG and the USDA. CDFA focuses on prevention of invasive plants, insects, and diseases of plants and livestock. DFG focuses on invasive animals including the quagga and zebra mussels. CDFA's exclusion branch includes inspection stations on major highways entering the state and enforcement of quarantines and inspection of packages at parcel carrier terminals within the state. CDFA also provides oversight of nurseries in California (CDFA 2008b). Once finalized, a new amendment to Section

3060.3, Title 3 of the California Code of Regulations will make it illegal for plants classified as noxious weeds to be sold as nursery stock.

CDFA has a program to eradicate hydrilla in Clear Lake and other water bodies in the state. The Clear Lake program, headquartered in Lakeport, has crews that survey the lake and apply herbicides to control hydrilla from April through mid-October. The number of boat crews has increased from three in 2007 to five in 2009 (CDFA 2007, Patrick Akers personal communication).

Many CDFA activities are carried out by county Agricultural Commissioner offices. In Lake County, the Agriculture Department (LCAD) has trapping programs for Japanese beetle, Mediterranean, Mexican, Melon and Oriental fruit flies, the Glassy-winged sharpshooter, Vine mealybug, Light brown apple moth, and Gypsy moth. They have programs to eradicate Skeleton weed and to prevent the spread of Leafy spurge. They also carry out control of Scotch thistle and purple star thistle depending on the availability of funding. The LCAD also carries out inspections of packages to local carriers and plant shipments to local nurseries (Steve Hajik, personal communication).

The Lake County Weed Management Area (LCWMA), formed in 2001, is a group that cooperates and coordinates activities and expertise to prevent and control weed problems in Lake County. It is made up of the Lake County Agricultural Commissioner's office, the Lake County Public Works Department, the East and West Lake Resource Conservation Districts, and the local office of the NRCS, with local Tribes, other governmental agencies, environmental, and industry groups as partners. Its activities are "focused upon the exclusion, detection, suppression, and eradication of noxious and invasive non-native weeds" (LCWMA 2008).

Starting in 2001 the LCPWD has had a program to monitor and eradicate arundo and inventory tamarisk throughout the county. Currently funding for tamarisk monitoring and eradication continues.

In Clear Lake, aquatic weeds are managed under the CEQA- approved IAPMP, approved by the Board of Supervisors in 2005. Objectives of the plan include supporting the continued multiple uses of Clear Lake, identifying effective and environmentally sound management techniques, avoiding adverse human and environmental impacts, and minimizing potential introduction of non-native species to Clear Lake (Jones & Stokes 2005).

16.10 Fire Hazard Management

CAL FIRE is responsible for fire protection in the Kelsey Creek Watershed with the exception of the local responsibility area of the Kelseyville Fire Department. Within the watershed, CAL FIRE has the Kelsey-Cobb Fire station and the Boggs Mountain Demonstration State Forest Helitack station, both of which are open only during the fire season. CAL FIRE is contracted to provide fire protection services by the South Lake Fire Protection District (SLFPD), the district from the southern end of the county to Lower Lake. The SLFPD has a year-round station at Cobb that is manned around the clock. During a wildfire, personnel and equipment from all the above stations and the CAL FIRE station in Clearlake Oaks may be called (Jim Wright, personal communication).

The SLFSC is affiliated with the SLFPD, and its mission is to reduce fire risk. In the Cobb Mountain area, and south to the county line, the SLFSC sponsors educational workshops and provides free chipping services to neighborhood groups (SFLSC 2007). Along with creating fire breaks adjacent to subdivisions in the Cobb area, they have plans to create a fire break along Bottle Rock Road to permit safe escape from fire and defensible space for fire crews.

The Lake County Fire Safe Council hired a consultant to complete a Community Wildfire Protection Plan (CWPP) for the entire county. Ten meetings were held around the county in October 2008 to gather local input on the CWPP. Local, state, and federal fire protection organizations and other interested parties were involved in developing and reviewing the plan. The plan includes chapters on wildfire behavior, fire ecology, Lake County community features, fire protection organizations, risk assessment, and an action plan. The action plan includes sections on advancing defensible space, reducing fuels and structural ignitability, enhancing fire protection, evacuation planning, and fire safe education. The plan was approved by the Lake County Board of Supervisors in August 2009.

In January 2009, Lake County authorized short term funding for a Fire Safe Coordinator whose duties will be to implement the Community Wildfire Protection Plan and to assist local communities in becoming Firewise Communities. The Firewise Community website offers excellent education for homeowners (Appendix D).

Landowners wishing to carry out prescribed burns should start by contacting the California Department of Forestry and the Lake County Air Quality Management District (the local office of the state Air Resources Board).

The Lake County General Plan includes goal HS-7 “to minimize the possibility of the loss of life, injury, or damage to property as a result of urban and wildland fire hazards.” Policies to reach this goal include support of fuel reduction programs, requiring wildland fire management plans for projects adjoining areas that may have high fuel loads, fire break requirements, and specific development guidelines for lands designated as high and extreme wildfire hazards (LCCDD 2008).

The state of California requires anyone owning, leasing, or otherwise responsible for buildings in wildfire hazard areas to maintain a defensible space around the building. (See Appendix D for resources on defensible space.) CAL FIRE inspects new buildings for compliance with defensible space requirements. They also inspect other buildings when they receive complaints and when time permits (Jim Wright, personal communication).

Landowners wishing to carry out prescribed burns should contact the Lake County Air Quality Management District and CAL FIRE. CAL FIRE can provide technical advice on prescribed burning, and in some instances, when a large area of brushland is involved, CAL FIRE can cost share and provide expertise for prescribed burning.

16.11 Prevention of Illegal Dumping

Lake County combats illegal dumping in several ways. The Lake County Public Services Department (LCPSD) has contracted with two private franchise haulers to provide low cost curbside trash pick-up and recycling. The county also sponsors a free mobile household hazardous material program that is available to residents about once a month to dispose of paint, chemicals, small propane tanks, fluorescent lights, and unusable over-the-counter or prescription drugs.

LCPSD, and CED, have a prevention program that encourages residents to use low cost or free disposal and amnesty programs. They educate the public about low-cost/no-cost options for waste disposal through such means as brochures, flyers, a recycling website, newspaper articles, and radio announcements. Enforcement is another approach to prevention. The penalty for illegal dumping (a misdemeanor) is a fine of up to $100 and up to 30 days in jail, or both. Complaints can be reported to CED, (707) 263-2309 or to their 24 hour hotline, (707) 263-2308.

Illegal waste clean-up on private property is enforced by CED. They also apply for grant funding to clean up illegal dumpsites. For example, they received $35,000 to clean up 17 illegal dumpsites in the county in 2007-2008. When clean-ups involve a health and sanitation issue, Environmental Health Division (EHD) is involved. EHD has funding for clean-up of drug lab chemicals. They have grant funding to ensure that local businesses properly dispose of tires, and this funding includes some money for clean-up of illegally dumped tires.

CED, EHD, and the Lake County Sheriff's Department investigate reports of illegal dumping. Enforcement is difficult, due to a lack of state guidance on what constitutes sufficient evidence to prove that illegal waste disposal has occurred. Therefore, the Sheriff's Office gets involved when there is prosecutable evidence, such as an eyewitness to the illegal dumping. The DFG enforces state law that prohibits dumping within 150 feet of a water body. The state number to report illegal dumping is (888) DFG-CALTIP.

This number is to report both poachers and polluters, and if the reported information leads to an arrest, the reporter is eligible for a reward.

Figure 16.1 Trash dumped in the Kelsey Creek floodplain, May 3, 2008. *Photo by Jennifer and Kevin Ingram.*

16.12 Land Use Planning

The first goal of the General Plan for Lake County (2008) is to encourage economic and social growth in the county while maintaining quality of life. In part this is to be done by clearly differentiating "between areas within Lake County appropriate for higher intensity urban services and land uses (i.e., high density residential, high density commercial, and industrial) from areas where rural or resource use should be emphasized." The Lake County Zoning Ordinance establishes specific districts (for example agricultural, rural residential and resort commercial districts) and the standards for land use and construction in those districts (Lake County 2008). The Community Development Department prepares updates to the county General Plan and to area plans (for example the Kelseyville Area Plan). They are responsible for enforcing compliance with the zoning ordinance. The Planning Commission consists of five members, each appointed by the supervisor in their district for a two year term. Their duties are to hold public hearings on proposed zoning, to hear and decide use permit applications and applications for variances, to consider maps of proposed subdivisions, and to investigate and make recommendations to the Board of Supervisors with regard to public projects and acquisitions.

16.13 Cultural Resource Management

Potential cultural resources are identified when projects require initial inspection under California law (CEQA sec. 15064.5, 15065 a, 21083.2, 21084.1). The historical or archeological resource comes under the protection of CEQA if it is significant or unique enough to be included in the California Register of Historic Resources including that it:

- Is associated with events that have made a significant contribution to the broad patterns of California's history and cultural heritage.
- Is associated with the lives of persons important in our past.
- Embodies the distinctive characteristics of a type, period, region, or method of construction, or represents the work of an important creative individual, or possesses high artistic values.
- "Has yielded, or may be likely to yield, information important in prehistory or history." (CEQA Sec. 15064.5)

The first phase of inspection is a background record search, and inspection of the site by a qualified archeologist. In some cases, a small test excavation is necessary to determine the significance of the cultural resource.

When a unique archeological resource is found, CEQA requires the agency involved to first consider alternatives that preserve the resource in place and in an undisturbed state. Additional regulations apply if the resource cannot be left in place (CEQA sec 21083.2). When the inspection finds the existence or probable existence of Native American remains within the project, the permitting agency must work with the appropriate Native Americans as identified by the Native American Heritage Commission. Accidental discovery of human remains requires determination by the County Coroner as to whether they are Native American and contact of the Native American Heritage Commission if they are. Agreements are then made for "treating or disposing of, with appropriate dignity, the human remains and any associated grave goods" (CEQA section 15064.5).

Impairment to historical resources can be mitigated to a non-significant level by following federal guidelines for preservation and restoration of historic properties or by other measures identified by the permitting agency (CEQA sec 15064.5).

16.14 Watershed Education

In many cases the regulatory and management agencies mentioned above are excellent sources of information to watershed users. In addition, some government agencies have the primary mission of technical assistance and education. The NRCS, with an office in Lakeport, provides technical and financial resources to landowners in areas such as soil conservation, wildlife habitat improvement, range and forest land improvement, and sustainable agriculture. The University of California Cooperative Extension office in Lakeport also provides education and technical resources in these areas.

Clear Lake State Park, located at the mouth of Kelsey Creek, has a visitor center offering interpretive displays on the natural, cultural, and recreational resources of Clear Lake. The Clear Lake State Park Interpretive Association (CLSPIA) supports the park and visitor center through fund raisers and gift shop sales to provide docent training programs, maintain the visitor center exhibits, and fund the summer Junior Ranger Program. The Junior Ranger Program has been providing outdoor education to children since 1975. Following a four year fund raising effort, the CLSPIA has signed contracts to begin construction of an Outdoor Education Pavilion to support the park's education mission in 2009. During the summer Park Rangers offer weekly campfire talks on environmental topics and support the educational programs discussed above.

The Big Valley Watershed Group conducts watershed education events as part of its monthly meetings and in outdoor settings. The East and West Lake RCDs organized an oak tree education and propagation program in cooperation with the Kelseyville Future Farmers of America organization.

17.0 Findings and Recommendations

17.1 Watershed Issues

Prior to compiling this watershed assessment, the Big Valley watershed group held several meetings to identify issues of concern in the watershed. This process was to insure that the assessment includes information on topics considered vital by watershed users. In this chapter assessment findings in relation to each issue of concern are briefly reviewed, and data gaps are identified.

17.1.1 Protecting Water Quality

Sediment is the most widely recognized pollutant to watershed surface waters with the potential to damage stream aquatic habitats and Clear Lake water quality. It is also the source of mercury and nutrients, the two contaminants under regulatory requirements for clean up (TMDLs) for Clear Lake. Sediment studies to date have measured the total sediment load from the Kelsey Creek Watershed to Clear Lake. There have not been studies to determine whether sediment sources are localized within the watershed and what activities are causing accelerated erosion. The most recent survey of stream channel conditions, covering 15.5 miles of Kelsey Creek, was carried out in 1985. Documentation of current conditions and areas with accelerated streambank erosion is needed. Funding is necessary to conduct stream channel and sediment source inventories in the Kelsey Creek Watershed. Additional funding will be needed for identification, design, and implementation of erosion control projects.

Monitoring efforts for other potential surface water pollutants (for example the irrigated lands stream monitoring) have not detected significant contamination, but the monitoring has been limited in scope.

DWR stream water quality samples found many primary drinking water standard exceedances for a station labeled “Bottle Rock Power Plant” during sampling carried out from 1978-1987. It was not clear whether this sample came from a stream, waste pond, or other location. Follow up sampling is needed to determine whether there is an on-going contamination problem from the Bottle Rock Power Plant, especially as the plant was re-opened in 2007 after 16 years of closure.

Extensive stream bioassessment monitoring was carried out by DWR from 1979-1999. A single location was sampled by local volunteers in 2006. Continued bioassessment monitoring has the potential to integrate and track the effect of watershed activities on water quality and aquatic ecosystems. It has the added benefit of involving local residents in watershed activities.

Groundwater studies have detected increasing levels of nitrate, a potential human health threat, in some areas of Big Valley. The nitrate source could be from agricultural fertilizers and/or human/animal waste. The studies also detected localized areas with elevated levels of iron, boron, and magnesium to calcium ratios due to geothermal influences. These studies found that more groundwater quality data is needed to describe these changes. In particular, there are insufficient data to make conclusions with regard to the effects of low water levels on water quality (Christensen Associates Inc. 2003).

17.1.2 Managing Water Supply

Agriculture is the biggest water user in Big Valley. Because of recent changes in cropping patterns, current demand on water resources is reduced from past years. Aquatic habitats and spawning fish such as the Clear Lake hitch may benefit from this reduced agricultural water demand. It is important to plan for changes in cropping and other land use patterns that could lead to greater water demand.

17.1.3 Reducing Fire Hazards

Fuel loads and fire hazard are high throughout the upper Kelsey Creek Watershed, both because it is a naturally fire-prone area, and because there has been no significant wildfire in the area since 1962. At the same time more people continue to move to this fire-prone area. Prescribed burning and other practices to reduce fuel load are complicated by land ownership patterns, regulatory requirements, and cost. The recently completed Lake County Community Wildfire Protection Plan prioritizes fuel reduction and fire safety projects. On a local level, residents can organize Firewise Communities to work together on fire prevention.

17.1.4 Reducing Illegal Dumping

Reducing illegal dumping has been an issue of concern for the Big Valley Watershed Council since its inception. The group has carried out annual creek clean-ups since 2001. CED and LCPSD have programs for illegal dumping prevention. They work with the County Sheriff's Department and the DFG to catch violators, and the DFG enforces state laws prohibiting illegal dumping. Public Services continues to work closely with the Big Valley Watershed Council's cleanup efforts by providing fee waivers for trash and recyclables collected during annual cleanups. Use of surveillance equipment at illegal dumpsites has the potential to increase arrests and prosecutions for illegal dumping.

17.1.5 Flood Management and Debris Jams

Watershed users frequently consider debris jams in the context of flood control and the need for removal to prevent flooding. Straight, clear channels, can more rapidly move water through an area, however debris jams and meandering channels help to provide diverse riparian and aquatic habitat. When possible, land use practices that allow natural stream processes to occur should be encouraged. When debris jam removal is necessary, it may be necessary to contact government agencies for permits (Section 16.3). Hydrologic studies are needed along Kelsey Creek in the upper watershed to investigate the cause(s) of streambank erosion and debris jams.

17.1.6 Improvement of Lower Kelsey Creek Channel Conditions

The channel of Kelsey Creek below the lower falls has been altered significantly, especially the section from the town of Kelseyville to the lake. This section has down-cut from 10-25 feet due to gravel mining and modifications at the mouth of the creek. Riparian vegetation in the heavily mined area was virtually absent in the past, but has been improving since the elimination of gravel mining in the 1980s. The detention structure and upstream gravel retention structures have helped stabilize the channel above the detention structure. A survey of current channel conditions is needed in order to identify priorities for restoration and erosion control.

17.1.7 Restoration of Native Fish Populations

The Sacramento pikeminnow, Sacramento sucker, and Clear Lake hitch are three native fish whose populations were once much greater in Clear Lake, and in spawning runs in tributary streams. The Chi Council is "dedicated to the study, protection, and restoration of a viable population of *Lavinia exilicauda chi* (the Clear Lake hitch) within a healthy watershed ecosystem." A survey of all potential barriers to hitch migration is needed in order to prioritize efforts to improve stream access. Studies of the hitch life cycle and factors determining spawning success and lake survival are also needed. Improvement of channel conditions and aquatic habitat would potentially benefit all three native fish populations.

17.2 Information and Data Gaps

The following data and information gaps were identified through this watershed assessment process:

- Road and trail contribution to sedimentation and erosion.
- Current channel and riparian vegetation conditions.
- Updated flood zone mapping.
- Seasonal and drought-related changes in aquifer levels and quality.
- DWR 2006 land use survey completion.
- Oak regeneration status.
- Fish migration barrier inventory.

17.3 Recommendations

Projects for watershed management and restoration that were identified through this assessment process include the following:

- Assemble watershed fuel loading information.
- Identify and implement fuel load reduction projects.
- Continue inventory, mapping, and management of invasive plants.
- Expand oak tree propagation and education program.
- Inventory, evaluate, and enhance riparian corridor health.
- Complete hydrologic study to determine causes of streambank erosion, debris jams in upper watershed.
- Identify and implement streambank/channel stabilization projects to reduce erosion.
- Identify and implement projects to remove damaging debris jams.
- Survey unpaved road and trail conditions and encourage erosion control BMPs for repair, design, and construction.
- Monitor stream water quality above and below the Bottle Rock Power Plant.
- Complete further analysis of DWR BMI data set.
- Continue volunteer stream bioassessments to monitor watershed health.
- Continue educational and clean-up projects to eliminate illegal dumping.
- Install surveillance cameras at illegal dumpsites.
- Inventory fish populations throughout the watershed with electrofishing surveys or other methods.

- Remove barriers or develop structures to permit fish passage, Kelseyville Main St. bridge is first priority.
- Pursue funding to study biology of Clear Lake hitch.

18.0 Glossary

Term	Definition	Source
Acre-ft	A unit of volume commonly used in the United States in reference to large-scale water resources. It is a volume equivalent to the area of one acre (43,560 square feet) covered to a depth of one foot.	W
Alluvial material, alluvium	Soil or sediments deposited by a river or other running water.	W
Anadramous fish	Fish who live mostly in the ocean and breed in freshwater.	w
Aquifer	An underground layer of porous, water-bearing rock, gravel, or sand.	MDC
Aquifer, confined vs. unconfined	Unconfined aquifers are covered by permeable geologic formations. They receive recharge water directly from the surface, from precipitation or from a body of surface water (e.g., a river, stream, or lake) which is in hydraulic connection with them**. Confined** aquifers have an impermeable layer at their upper boundary and are typically found below unconfined aquifers. Confined aquifers can be under pressure causing artesian wells, where water rises in the well, sometimes to the land surface.	W
Average Annual flow	The rate at which water flows through a channel, determined by averaging daily measurements of the flow during one entire year.	
Bankfull streamflow	Bankfull streamflow is the stage at which the flow that just fills the channel to the top of its banks.	
Benthic	Bottom-dwelling; describes organisms which reside in or on any underwater substrate.	MDC
Benthic macroinvertebrate	Bottom-dwelling (benthic) animals without backbones (invertebrate) that are visible with the naked eye (macro). They include crayfish, mollusks, aquatic worms, and the immature forms of aquatic insects, for example stonefly and mayfly nymphs.	MDC
Channelization	The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.	MDC
Cubic feet per second (cfs)	A measure of the amount of water (cubic feet) traveling past a known point for a given amount of time (one second).	MDC
Discharge	Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic feet per second.	MDC
Dissolved oxygen	The concentration of oxygen dissolved in water, expressed in milligrams per liter or as percent.	MDC
Diversion	A temporal removal of surface flow from the channel	CA SSHRM
Downcutting	When a stream channel deepens over time.	CWMP
Elevation	The vertical reference of a site location above mean sea level, measured in feet or meters.	CWMP
Endangered	In danger of becoming extinct.	MDC
Endemic	Native species found only in a particular geographic area with comparatively restricted habitat and distribution.	CWMP
Erodibility	The ease by which a soil may be eroded by natural forces or human disturbances.	CWMP
Eutrophic	Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae. Decay of this plant life often leads to low dissolved oxygen content. Lakes can be naturally eutrophic or can become eutrophic due to human activities that increase water nutrient levels.	MDC
Eutrophication	The process of increasing nutrient and decreasing oxygen supply within a water body.	CWMP
Evapotranspiration (ET)	The total amount of water transferred from earth to atmosphere including evaporation from surfaces and transpiration from plants (water loss due to plant metabolism).	CWMP
Fault	In geology, a fault or fault line is a planar fracture in rock in which the rock on one side of the fracture has moved with respect to the rock on the other side. Large faults within the Earth's crust are the result of differential or shear motion and active fault zones are the causal locations of most earthquakes. Earthquakes are caused by energy release during rapid slippage along a fault.	W
Flood	Any flow that exceeds the bankfull capacity of a stream or channel and flows out on the floodplain.	CA SSHRM
Flood Attenuation	To reduce the severity of floods, generally by water storage in wetlands or spread in natural floodplains.	CWMP

Flood Peak	The highest amount of flow that occurs during a given flood event.	CWMP
Floodplain	The flat area adjoining a river channel constructed by the river in the presence of a given climate, and overflowed at times of high river flow.	CWMP
Fire break	A firebreak (also called a fireroad, fire line or fuel break) is a gap in vegetation or other combustible material that acts as a barrier to slow or stop the progress of a bushfire or wildfire.	W
Fuel load	The dry weight of fuel (live and dead vegetation) per area	SAF
Gaging Station	A selected section of a stream channel equipped with a gage, recorder, or other facilities for measuring stream discharge.	CWMP
Geomorphology	The scientific study of landforms and the processes that shape them.	W
GIS	The combination of hardware and software used to store and analyze features located on the earth's surface. (Geographic Information System)	CWMP
Groundwater	Water that is located beneath the ground surface in soil pore spaces and in the fractures of lithologic formations.	CWMP
Gully		
Headwaters	The small streams and upland areas that are the source of larger streams and rivers. The most distant point in the drainage basin from the river or stream mouth.	CWMP, W
Hydrology	The study of the movement, distribution and quality of water throughout the earth (and atmosphere).	W
Hydrophobic soils	Soils that do not easily absorb water, and thus increase the rate of surface runoff.	CWMP
Impaired water body	Surface waters identified by the Regional Water Quality Control Boards as impaired because water quality objectives are not being achieved or where the designated beneficial uses are not fully protected after application of technology-based controls. A list of impaired water bodies is compiled by the State Water Resources Control Board pursuant to section 303(d) of the Clean Water Act (CWA).	SWGP
Impervious surface	Surface (such as pavement) that does not allow, or greatly decreases, the amount of infiltration of precipitation into the ground.	CWMP
Incised	Deep, well defined channel with narrow width to depth ratio, and limited or no lateral movement. Often newly formed, and as a result of rapid down-cutting in the substrate	MDC
Infiltration (water)	Entry of water into soil or other material at the earth's surface.	
Infiltration rate	The rate at which water penetrates the earth's surface.	CWMP
Invasive species	Plant or animal species from another geographic region that once introduced out-compete native plants or animals and take over a habitat area.	CWMP
Lacustrine	Relating to a lake.	W
Ladder fuels	A fuel ladder is a firefighting term for live or dead vegetation that allows a fire to climb up from the forest floor into the tree canopy. Common fuel ladders include tall grasses, shrubs, and tree branches, both living and dead.	W
Land use	Typically a group of similar on-the-ground human uses described as a single category.	CWMP
Large woody debris (LWD)	Logs, stumps, or root wads in the stream channel, or nearby. These function to create pools and cover for fish, and to drop and sort stream gravels.	CWMP
Maar	A broad, low-relief volcanic crater that is caused by an explosion when groundwater comes into contact with hot lava or magma. A maar characteristically fills with water to form a relatively shallow crater lake.	W
Meandering	When a stream channel has a winding or sinuous path.	CWMP
Metamorphic rock	Metamorphic rock is one of the three main rock types. (The others being sedimentary and igneous.) Itis the result of the transformation of an existing rock type by heat and pressure (temperatures greater than 150 to 200 °C and pressures of 1500 bars[1]) causing profound physical and/or chemical change. The existing rock may be sedimentary rock, igneous rock or another older metamorphic rock.	W
National Pollutant Discharge Elimination System (NPDES) Permit Program	Controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discrete conveyances such as pipes or man-made ditches. Since its introduction in 1972, the NPDES Permit Program has been responsible for significant improvements to our Nation's and State's water quality.	SWGP
Non-native species	Plant or animal species introduced to an area from another geographic region.	CWMP

Nonpoint Source (NPS) Pollution	Water pollution that does not originate from a discrete point, such as a sewage treatment plant outlet. NPS pollution is a by-product of land use practices, such as those associated with farming, timber harvesting, construction management, marina and boating activities, road construction and maintenance, and mining. Primary pollutants include sediment, fertilizers, pesticides and other pollutants that are picked up by water traveling over and through the land and are delivered to surface and ground water via precipitation, runoff, and leaching. From a regulatory perspective, pollutant discharges that are regulated under the National Pollutant Discharge Elimination System Permit (NPDES) are considered to be point sources. By definition, all other discharges are considered NPS pollution.	SWGP
Oceanic crust	Oceanic crust is the part of Earth's lithosphere (outermost, rocky layer) that surfaces in the ocean basins. It has a different composition and is thinner and denser than continental crust.	W
Peak flow	The maximum instantaneous rate of flow during a storm or other period of time.	CWMP
Percolation	The act of surface water infiltrating into and through the ground.	CWMP
Perennial streams	Streams fed continuously by a shallow water table and flowing year-round.	MDC
Planktivore	A general term to describe an organism adapted to feeding primarily on plankton (drifting organisms in water).	W
Plate (tectonic)	Large sections of the Earth's lithosphere (outer-most, rocky layer). There are currently 8 major (for example the North American and Pacific Plates) and many minor plates.	W
Point source	Source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant.	MDC
Precipitation	The liquid equivalent (inches) of rainfall, snow, sleet, or hail collected by storage gages.	CWMP
Prescribed burning	Also know as controlled or hazard reduction burning. Usually conducted during the cooler months to reduce fire fuel buildup and decrease the liklihood of serious, hotter fires.	W
Recurrence Interval (return interval)	Determined from historical records. The average length of time between two events (rain, flooding) of the same size or larger. Recurrence intervals are associated with a probability. (For example, a 100-year flood would have a 1% probability of happening in any given year.)	CWMP
Rill	A small channel formed when soil is removed by surface runoff. The channel is small enough to be erased by normal tillage.	CA SSHRM
Riparian Area	Interface between land and a stream.	W
Riparian Vegetation	Vegetation growing on or near the banks of a stream or other body of water in soils that are wet during some portion of the growing season.	CWMP
Sediment	Fragment material that originates from weathering of rocks and decomposition of organic material that is transported by, suspended in, and eventually deposited by water or air, or is accumulated in beds by other natural phenomena.	CA SSHRM
Sedimentary rock	Sedimentary rock is one of the three main rock types (the others being igneous and metamorphic rock). Sedimentary rock is formed by deposition and consolidation of mineral and organic material and from precipitation of minerals from solution. The processes that form sedimentary rock occur at the surface of the Earth and within bodies of water.	W
Sedimentation	The deposition or accumulation of sediment.	CWMP
Sediment	Fragments of rock, soil, and organic material transported by and deposited into streambeds by wind, water, or gravity.	CWMP
Stakeholder	A person, group, organization, or system who affects or can be affected by an action.	W
Stand-replacing fire	A fire of enough severity, at a local level, to kill all the mature trees.	CWMP
Stormwater	The surface water runoff resulting from precipitation falling within a watershed.	CWMP
Stream aggradation	When a stream, or section of stream, is depositing more material than it is removing, thereby raising the level of the stream.	
Stream degradation	When a stream, or section of stream, is removing more material than it is depositing. The level of the streambed is dropping, and usually the banks are eroding.	
Stream gage	A stream gauge, or stream gage, refers to a site along a stream where measurements of volumetric discharge (flow) are made.	
Stream gradient	The change of a stream in vertical elevation per unit of horizontal distance.	MDC

Stream order	A hierarchical ordering of streams based on the degree of branching. A first order stream is an unbranched or unforked stream. Two first order streams flow together to make a second order stream; two second order streams combine to make a third order stream. Stream order is often determined from 7.5 minute topographic maps.	MDC
Streamflow	The active flow of water within a stream, river, or creek. The volume of water passing a given point per unit of time.	CWMP
Subduction	In geology, subduction is the process that takes place at convergent boundaries by which one tectonic plate moves under another tectonic plate, sinking into the Earth's mantle, as the plates converge.	W
Substrate	The mineral and/or organic material forming the bottom of a waterway or waterbody.	MDC
Sub-watershed	Watersheds drain into other watersheds in a hierarchical form, larger ones breaking into smaller ones, or sub-watersheds, with the topography determining where the water flows.	W
Surface fuels	Low-lying vegetation such as leaf and timber litter, debris, grass and any other flammable material.	W
Surface runoff	Water that runs across the top of the land without infiltrating into the soil.	CWMP
Surface water	Water that is flowing across or contained on the surface of the earth, such as in rivers, streams, creeks, lakes, and reservoirs.	CWMP
Sustainable	Resources must only be used at a rate at which they can be replenished naturally.	SWGP
Threatened	A species likely to become endangered within the foreseeable future if certain conditions continue to deteriorate.	MDC
Tributary	A stream feeding, joining, or flowing into a larger stream or into a lake.	
Tuff	Tuff is a type of rock consisting of consolidated volcanic ash ejected from vents during a volcanic eruption.	W
Ultramafic	Describing igneous or metamorphic rocks that contain magnesium and iron and only a very small amount of silica, such as are found in the Earth's mantle. Often only specially adapted plants can survive on soils formed from these rocks.	W
Upland	Describing high or hilly country.	FD
Upland Vegetation	Vegetation typical for a given region, growing on drier soils. The same plant species may grow in both riparian and upland zones.	CWMP
Watershed	The total land area that water runs over or under when draining to a stream, river, pond, lake, or other designated point.	MDC
Weir	A low dam placed in a river or stream to raise its level, divert its flow, or gage the flow of water.	CWMP
Wetland	A wetland is an area of land whose soil is saturated with moisture either permanently or seasonally.	W
Wildfire	A wildfire is any uncontrolled fire that occurs in the countryside or wildland.	W
Wildland-urban interface	An area where human development meets or is intermingled with forest, brushland and grassland fuel types.	
	Sources of Definitions	
CA SSHRM	CA Department of Fish and Game Salmonid Stream Habitat Restoration Manual <http://www.dfg.ca.gov/fish/REsources/HabitatManual.asp>	
CWMP	Carlsbad Watershed Management Program <http://www.carlsbadwatershednetwork.org/cwmp.php> (Accessed 03.10.09).	
FD	The Free Dictionary. <http://www.thefreedictionary.com>	
MDC	Missouri Department of Conservation, MDC.online watershed glossary. http://mdc.mo.gov/fish/watershed/glossary.htm (Accessed 03.10.09)	
SAF	Society of American Foresters. The Dictionary of American Forestry <http://dictionaryofforestry.org/dict/browse> (Accessed 07.14/09)	
SWGP	Proposition 84 Storm Water Grant Program, Draft Final RFP	
W	Wikipedia - Free online Encyclopedia	

19.0 Acronyms

ARMP	Lake County Aggregate Resource Management Plan
BMDSF	Boggs Mountain Demonstration State Forest
BMI	Benthic macroinvertebrate
CAL FIRE	California Department of Forestry and Fire Protection
CDBW	California Department of Boating and Waterways
CDD	Lake County Community Development Department
CDFA	California Department of Food and Agriculture
CED	Code Enforcement Division of Lake County CDD
CEQA	California Environmental Quality Act
CLTSC	Clear Lake TMDL Stakeholder Committee
CNDDB	California Natural Diversity Database
CRMP	Coordinated Resource Management Planning
CVRWQCB	Central Valley Regional Water Quality Control Board
CWHR	California Wildlife Habitat Relationships
CWPP	California Wildfire Protection Program
DFG	(California) Department of Fish and Game
DPR	California Department of Pesticide Regulation
DWR	Department of Water Resources
EHD	(Lake County) Environmental Health Division
EIR	Environmental Impact Report
FEMA	Federal Emergency Management Assistance
IAPMP	Clear Lake Integrated Aquatic Plant Management Plan
IRWMP	Integrated Regional Water Management Plan
LCAD	Lake County Agriculture Department
LCCWP	Lake County Clean Water Program
LCLT	Lake County Land Trust
LCPWD	Lake County Public Works Department
LCWMA	Lake County Weed Management Area
NFIP	National Flood Insurance Program
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service (formerly SCS)
RCD	Resource Conservation District
SLFPD	South Lake Fire Protection District

SLFSC	South Lake Fire Safe Council
SOD	Sudden Oak Death
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WLRCD	West Lake Resource Conservation District

20.0 References

Agee, J.K. 2006. 'Foreword' in N.G. Sugihara, J.W. Van Wagtendonk, J. Fites-Kaufman, K.E. Shaffer and A.E. Thode (Editors) *Fire in California's Ecosystems*. University of California Press, Berkeley.

Agee, J. K. 2007. The Role of Silviculture in Restoring Fire-Adapted Ecosystems in R.F. Powers (Editor) Restoring Fire-Adapted Ecosystems: Proceedings of the 2005 National Silviculture Workshop. USDA Forest Service General Technical Report PSW-GTR-203.

Allison, G.M. and W.R. McIntire. 1949. From Letter to Mr. Mauldin from G.M. Allison and W.R. McIntire, Capitola, Calif. June 15, 1949. In Mauldin's History of Lake County, Lake County Museum, pp. 741-742.

Allen, B. and M. Pitkin. 2000. The Draft Grassland Bird Conservation Plan: A Strategy for Protecting and Managing Grasslands and Associated Birds in California. Version 1.0 A Project of California Partners in Flight and Point Reyes Bird Observatory. http://www.prbo.org/calpif/htmldocs/grassland.html (Accessed 03.24.08)

Anderson, M.K. 1993. The Mountains Smell Like Fire. Fremontia. Vol. 21, No. 4. pp. 15-20.

Anonymous. 2007. Forest Management Part IV: Managing Risks: Fire, Pests, Disease, and Other Undesired Challenges. Forestland Steward. CAL FIRE & UC Cooperative Extension. Winter 2007.

Audubon. 2008. Cowbirds and Conservation. http://www.audubon.org/bird/research/ (Accessed 05.27.08)

BEA, USDC (Bureau of Economic Analysis, United States Department of Commerce). 2008. Regional Economic Accounts, Per Capita Income. http://www.bea.gov/bea/regional/reis/drill.cfm (Accessed 05.07.08)

Barbour, M.G. and V. Whitworth. 2001. 'Natural Vegetation of the Putah-Cache' in Amy J. Boyer, Jan Goggans, Daniel Leroy, David Robertson, Rob Thayer (Editors) Putah and Cache: A Thinking Mammal's Guide to the Watershed. http://bioregion.ucdavis.edu/book/Contents.html (Accessed 05.02.08)

BLM (Bureau of Land Management). 1973a. United States Department of the Interior Bureau of Land Management Physical and Biological Stream Survey Report Kelsey Creek. Neil B. Armantrout Surveyor. Four stream sections. 16 July 1973.

BLM (Bureau of Land Management). 1973b. United States Department of the Interior Bureau of Land Management Physical and Biological Stream Survey Report Sweetwater Creek. Neil B. Armantrout Surveyor. Four stream sections. 17 July 1973.

BLM (Bureau of Land Management). 1975. United States Department of the Interior Bureau of Land Management Physical and Biological Stream Survey Report High Valley Creek. R.L. Johnson Surveyor. Aug 14, 1975.

Benson, H.W. and H. Mauldin. 1974. When Spawning Fish Died By Millions. Pomo Bulletin. In Mauldin's History of Lake County, Lake County Museum, pp. 8298-8300.

CPIF (California Partners in Flight). 2000. Version 1.0. The Draft Grassland Bird Conservation Plan: A Strategy for Protecting and Managing Grassland Habitats and Associated Birds in California (B. Allen, lead author). Point Reyes Bird Observatory, Stinson Beach, CA. http://www.prbo.org/calpif/plans.html (Accessed 03.24.08)

Brode, J.M. and R.B. Bury. 1984. The importance of riparian systems to amphibians and reptiles' in R.E. Warner and K.M. Hendrix (Editors) *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley: University of California Press. http://content.cdlib.org/xtf/view?docId=ft1c6003wp&chunk.id=d0e563&toc.depth=1&toc.id=d0e563&brand=eschol (Accessed 03.31.04)

CalPIF (California Partners in Flight). 2002a. Version 1.0. The Draft Coniferous Forest Bird Conservation Plan: A Strategy for Protecting and Managing Coniferous Forest Habitats and Associated Birds in California (J. Robinson and J. Alexander, lead authors). Point Reyes Bird Observatory, Stinson Beach, CA. http://www.prbo.org/calpif/plans.html (Accessed 03.24.08)

CalPIF (California Partners in Flight). 2002b. Version 2.0. The Oak Woodland Bird Conservation Plan: A Strategy for Protecting And Managing Oak Woodland Habitats and Associated Birds in California (S. Zack, lead author). Point Reyes Bird Observatory, Stinson Beach, CA. http://www.prbo.org/calpif/plans.html (Accessed 03.24.08)

CalPIF (California Partners in Flight). 2004. Version 2.0. The Coastal Scrub and Chaparral Bird Conservation Plan: A Strategy for Protecting and Managing Coastal Scrub and Chaparral Habitats and Associated Birds in California (J. Lovio, lead author). PRBO Conservation Science, Stinson Beach, CA. http://www.prbo.org/calpif/plans.html (Accessed 03.24.08)

CalPIF (California Partners in Flight). 2004. Version 2.0. The Riparian Bird Conservation Plan. A Strategy for Reversing the Decline of Riparian Associated Birds in California. http://www.prbo.org/calpif/pdfs/riparian_v-2.pdf (Accessed 03.24.08)

CDFA (California Department of Food and Agriculture). 2006. Plant Health and Pest Prevention Services Integrated Pest Control Branch. Hydrilla Eradication Program Annual Progress Report 2006.

CDFA (California Department of Food and Agriculture). 2007. CDFA Hydrilla Eradication Program Annual Progress Report 2007.

CDFA. (California Department of Food and Agriculture).2008. Update on Vine Mealybug Trapping and Distribution. www.cdfa.ca.gov/countyag/postings/files/Update_VMB_Distr.pdf Accessed 05.27.08)

CDFA. 2008b. Pest Exclusion Branch. http://www.cdfa.ca.gov/phpps/pe/ (Accessed 06.01.08)

CDFFP (California Department of Forestry and Fire Protection). 2001. Learning to Live with Fire. http://65.109.144.97/Fire/Learning%20to%20Live.pdf (Accessed 03.11.08)

CDFFP (California Department of Forestry and Fire Protection). 2005. Sonoma-Lake-Napa Fire Plan http://cdfdata.fire.ca.gov/fire_er/fpp_planning_plans_details?plan_id=69 (Accessed 03.10.08)

CDFFP (California Department of Forestry and Fire Protection). 2008. Boggs Mountain Demonstration State Forest Management Plan.

CDFG (California Department of Fish and Game). 1988. California Wildlife Habitat Relationships System. From K.E. Mayer and W.F. Laudenslayer, Jr. (Editors) *A Guide to Wildlife Habitats of California*. State of California, Resources Agency, Department of Fish and Game. http://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp#Tree (Accessed 03.24.08).

CDFG (California Department of Fish and Game). 2000. Clear Lake Fishery Management Plan. By Philip K. Bairrington.

CDFG (California Department of Fish and Game). 2005. A046 Bullfrog Rana catesbeiana. California Wildlife Habitat Relationship System. Database Version 8.1.

CDFG (California Department of Fish and Game). 2008. Non-native Invasive Species, New Zealand Mud Snail. http://www.dfg.ca.gov/invasives/mudsnail/ (Accessed 06.02.08)

CDM and DWR (California Department of Water Resources, Northern Districts). 2006a. Lake County Water Demand Forecast Final, March 2006.

CDM and DWR (California Department of Water Resources, Northern Districts). 2006b. Lake County Watershed Protection District, Lake County Water Inventory and Analysis, Final, March 2006.

CNDDB (California Natural Diversity Database) 2008. Quick viewer database queried for Lake County. http://imaps.dfg.ca.gov/viewers/cnddb_quickviewer/app.asp (Accessed 04.08.08)

COMTF (California Oak Mortality Task Force). 2004. History & Background. http://nature.berkeley.edu/comtf/html/history___background.html (Accessed 03.25.08)

CSMB, (California State Mining Bureau). 1890. Lake County. Tenth Annual Report of the State Mineralogist. Sacramento: J.D. Young, Superintendent, State Printing.

CVRWQCB (Central Valley Regional Water Quality Control Board). 2002. Clear Lake TMDL for Mercury, Staff Report, Final Report, February 2002.

CVRWQCB (Central Valley Regional Water Quality Control Board) 2006. Amendment to the water quality control plan for the Sacramento River and San Joaquin River Basins for the control of nutrients in Clear Lake, Staff Report June 2006.

CVRWQCB (Central Valley Regional Water Quality Control Board) 2008. A Compilation of Water Quality Goals.

Chi Council. 2008. Chi Council for the Clear Lake Hitch, Minutes of April 23, 2008 meeting at Lake County Agricultural Center. http://www.lakelive.org/chicouncil/minutes.htm (Accessed 05.15.08)

Christensen Associates Inc. 2003. Big Valley Ground Water Recharge Investigation Update. Prepared for the Lake County Flood Control and Water Conservation District.

CLTSC (Clear Lake TMDL Stakeholder Committee). 2008. Monitoring and Implementation Plan Clear Lake Mercury and Nutrient TMDL's. June 27, 2008 Draft.

Clements, D. & P. Clements. (Undated) Kelsey Creek Property Owner Evaluation as Requested by Coordinated Resource Management & Planning (CRMP) Chairpersons Earl Nelson & Ross England.

Cook, S.F. 1943. The Conflict Between the California Indian and White Civilization, I-IV. Ibero-Americana, Volumes 21-24. University of California Press, Berkeley, CA.

Cook, S.F. Jr., R.L. Moore, and J.D. Conners. 1966. The Status of the Native Fishes of Clear Lake, Lake County, California. The Wasmann Journal of Biology. Vol. 24, No. 1, pp 141-160.

County of Lake, Department of Agriculture. Various years. Agricultural Crop Reports.

DFG (California Department of Fish and Game). 1958. California Department of Fish and Game Stream Survey Kelsey Creek. 5-29-58.

DFG (California Department of Fish and Game). 1970a. The Resources Agency of California Department of Fish and Game Stream Survey Kelsey Creek July 20-23, 1970.

DFG (California Department of Fish and Game). 1970b. The Resources Agency of California Department of Fish and Game Stream Survey Sweetwater Creek July 22, 1970.

DFG (California Department of Fish and Game). 1970c. The Resources Agency of California Department of Fish and Game Stream Survey Lee Creek July 23, 1970.

DFG (California Department of Fish and Game). 1973. The Resources Agency of California Department of Fish and Game Stream Survey High Valley Creek. 20 August, 1973.

DFG (California Department of Fish and Game). 1974a. The Resources Agency of California Department of Fish and Game Stream Survey Kelsey Creek October 7-8, 1974.

DFG (California Department of Fish and Game). 1974b. The Resources Agency of California Department of Fish and Game Stream Survey Jones Creek October 8, 1974.

DFG (California Department of Fish and Game). 2000. Clear Lake Fishery Management Plan. by Philip K. Bairrington, Associate Fishery Biologist Central Coast Region. State of California The Resources Agency California Department of Fish and Game Wildlife and Inland Fisheries Division Fisheries Program Branch.

DFG (California Department of Fish and Game). 2008. Department of Fish and Game Lake and Streambed Alteration Program. <http://www.dfg.ca.gov/habcon/1600/> (Accessed 01.12.09).

Dillon, B.D. 1995. History and Prehistory of Boggs Mountain Demonstration State Forest Lake County, California. CDF Archaeological Reports Number 15, Volume 1 of 2. California Department of Forestry and Fire Protection Archaeology Office. Sacramento, California.

Donnelly-Nolan, J.M.. 1990. Contribution in Wood, C. A., and Kienle, Juergen, (Editors), 1990. Volcanoes of North America: United States and Canada: New York, Cambridge University Press.

EPA (United States Environmental Protection Agency). 2007. Overview of EPA Authorities for Natural Resource Managers Developing Aquatic Invasive Species Rapid Response and Management Plans: CWA Section 404-Permits to Discharge Dredged or Fill Material. http://www.epa.gov/owow/invasive_species/invasives_management/cwa404.html (Accessed 01.12.09).

FEMA (Federal Emergency Management Agency). 2002. National Flood Insurance Program, Program Description. http://fema.gov/library/viewRecord.do?id=1480 (Accessed 01.29.08)

Florsheim, J. 2007. Chapter 3. Fluvial Processes and Morphology Assessment Methods. In The California Watershed Assessment Manual Volume II. http://cwam.ucdavis.edu/ (Accessed 09.19.07)

Gibbs, G. 1860. Journal of the Expedition of Colonel Redic M'Kee, United States Indian Agent, through Northwestern California. Performed in the Summer and Fall of 1851. in Archives of Aboriginal Knowledge, 4. Henry R. Schoolcraft. Philadelphia: J.B. Lippincott & Society. Pp 99-177.

Harrington, J. and M. Born. 2000. Measuring the Health of California Streams and Rivers. A Methods Manual for Water Resource Professionals, Citizen Monitors, and Natural Resources Students. Sustainable Land Stewardship Institute. Sacramento, California.

Hearn, B.C. Jr. and R. J. McLaughlin. 1988. 'Tectonic framework of the Clear Lake basin, California' in J.D. Sims (Editor) *Late Quaternary Climate, Tectonism, and Sedimentation in Clear Lake, Northern California Coast Ranges Special Paper 214*. The Geological Society of America, Inc. Boulder, Colorado.

Jones & Stokes. 2005. Draft Programmatic Environmental Impact Report: Clear Lake Integrated Aquatic Plant Management Plan. Prepared for County of Lake Department of Public Works and Community Development Department.

Jordan D.S. and C.H. Gilbert. 1894. List of the fishes inhabiting Clear Lake, California. Bulletin of the United States Fish Commission. 14:139-140.

Keeley, J.E. 2002. "Native American Impacts on Fire regimes of the California Coast Ranges" *Journal of Biogeography*. Vol. 29. pp. 303-320.

Kreith, M. 2007. "Wild Pigs in California: The Issues" *Agricultural Issues Center Brief*. Number 33. December 2007.

LCCDD (Lake Count Community Development Department) 1995. Kelseyville Area Plan.

LCCDD (Lake Count Community Development Department). 2006. Lake County Grading Ordinance. County of Lake, State of California.

LCCDD (Lake Count Community Development Department). 2008. Lake County General Plan. County of Lake, State of California

LCFCWCD (Lake County Flood Control and Water Conservation District). 1999. Big Valley Groundwater Management Plan.

LCLT (Lake County Land Trust). 2008. Lake County Land Trust Conservation Priority Plan.

LCPD (Lake County Planning Department). 1981. County of Lake General Plan, Adopted November 1981, Addendums: 1988, 1992, 1997.

LCPD (Lake County Planning Department). 1989. Cobb Mountain Area Plan.

LCPD (Lake County Planning Department). 1992. Lake County Aggregate Resource Management Plan, An Element of the Lake County General Plan Adopted November 19, 1992.

LCRB (Lake County Record Bee). 2008. "Power Outrage" by Tiffany Revelle, staff reporter November 21, 2008.

LCS (Lake County Sheriff). 2008. Office of Emergency Services- What Can I Do to Help? http://lakesheriff.com/oes/whatcanido.asp (Accessed 01.12.09).

LCWMA (Lake County Weed Management Area). 2008. Memorandum of Understanting Lake County Weed Management Area.

LCWPD (Lake County Watershed Protection District). 2009. Final Report Clear Lake Watershed TMDL Monitoring Program.

Lake County. 1999. Lake County Watershed Assessment and Inventory Section 205j Water Quality Grant Water Quality Information. February 1999.

Lake County. 2000. Lake County Floodplain Management Plan. Adopted by the Lake County Board of Supervisors September 26, 2000.

Lake County. 2007. Grading Ordinance, Chapter 30 of Lake County Code.

Lake County. 2008. Lake County California Mussel Prevention page. http://www.co.lake.ca.us/Government/DepartmentDirectory/Water_Resources/Mussel_Prevention.htm (Accessed 06.01.08).

Lake County 2008. Zoning Ordinance. http://www.co.lake.ca.us/Government/DepartmentDirectory/Community_Development/Zoning_Ordinance.htm (Accessed 06.10.08).

Lake County Agricultural Commissioner. 2002. Invasive Weeds of Lake County.

NISC (National Invasive Species Council). 2006. Invasive species definition clarification and guidance white paper. Submitted by the Definitions Subcommittee of the Invasive Species Advisory Committee (ISAC). Approved by ISAC April 27, 2006. http://www.invasivespeciesinfo.gov/docs/council/isacdef.pdf (Accessed 05.30.08)

Lake County Department of Public Works. 2001. Kelsey Creek Detention Structure Operating Criteria.

Leopold, L.B. 1994. A View of the River. Harvard University Press, Cambridge Massachusetts.

Leopold, L.B. 1997. Water, Rivers and Creeks. University Science Books, Sausalito, California.

Macedo, R. 1994. Swimming Upstream Without a Hitch. Outdoor California. Vol. 55, No. 1. pp 1-5.

Marin Resource Conservation District. 2007. Groundwork A Handbook for Small-scale Erosion Control in Coastal California.

Mauldin, H.K. n.d. Offical Lake County History Files. Handwritten Ms. Excerpt copies, Boggs Mountain State Forest.

Mauldin, H.K. 1968. History of Clear Lake, Mt. Konocti and the Lake County Cattle Industry.

McBride, J.R. and J. Strahan. 1984. “Fluvial processes and woodland succession along Dry Creek, Sonoma County, California” in R.E. Warner and K.M. Hendrix (Editors) *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley: University of California Press. http://content.cdlib.org/xtf/view?docId=ft1c6003wp&chunk.id=d0e563&toc.depth=1&toc.id=d0e563&brand=eschol (Accessed 03.31.04)

McCreary, D.D. 2004. Fire in California’s Oak Woodlands. University of California Hardwood Range Management Program. http://danr.ucop.edu/ihrmp/ (Accessed 03.12.08)

McLendon, S. and M.J. Lowy. 1978. Eastern Pomo and Southeastern Pomo. In Handbook of North American Indians. Volume 8, pp 306-323. Smithsonian Institution. Washington D.C.

Minnich, R.A. and Ernesto Fraco-Vizcaino. 1999. Prescribed Mosaic Burning in California Chaparral. USDA Forest Service General Technical Report PSW-GTR-173.

Moores, E.M. and J.E. Moores. 2001. 'Geology of Putah-Cache: The Franciscan Complex' in Amy J. Boyer, Jan Goggans, Daniel Leroy, David Robertson, Rob Thayer (Editors) Putah and Cache: A Thinking Mammal's Guide to the Watershed. http://bioregion.ucdavis.edu/book/Contents.html (Accessed 04.16.08)

Moyle, P.B., R.M. Yoshiyama, J.E. Williams and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California, Second Edition. Prepared for the State of California, The Resources Agency, Department of Fish and Game, Inland Fisheries Division Rancho Cordova.

Murphy, G.I. 1948. Notes on the biology of the Sacramento hitch (*Lavinia e. exilicauda*) of Clear Lake, Lake County, California. California Fish and Game, 34(3):101-110. Excerpts in Mauldin's History of Lake County, Lake County Museum. pp. 1792-1794.

Murphy, G.I. 1951. The Fishery of Clear Lake, Lake County, California. California Fish and Game, 37(4):439-484. pp. 1388-1409.

NIFC (National Interagency Fire Center). 2008. Chapter 2. Part D. Fire Dependent Ecosystems of the United States. In Wildland Fire Communicators Guide. http://www.nifc.gov/preved/comm_guide/wildfire/index.htm (Accessed 03.12.08)

NRCS (Natural Resources Conservation Service). 1998. Stream Corridor Restoration Principles, Processes and Practices. 10/98 Published Version, Revised 8/2001. http://nrcs.usda.gov/technical/stream_restoration/newtofc.htm (Accessed 01.03.08)

Nunamaker, C. 2002. Fire Cycles. California Forest Stewardship Program website. http://www.ceres.ca.gov/foreststeward/html/firecycles.html (Accessed 03.13.08)

Ortiz, B.R. 2006. Wild gardens: How Native Americans shaped local landscapes. Bay Nature. January-March 2006. http://baynature.com/2006janmarch/wildgardens.html (Accessed 03.11.08)

RHJV (Riparian Habitat Joint Venture). 2004. Version 2.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight. http://www.prbo.org/calpif/pdfs/riparian.v-2.pdf. (Accessed 03.11.08)

Richerson, P.J. and S.O. Richerson. 2000. The ample charms of a well-fed lake. In Putah/Cache Bioregion Guidebook. Draft 3.6.

Richerson, P.J. , T.H. Suchanek and S.J. Why. 1994. The Causes and Control of Algal Blooms in Clear Lake. Clean Lakes Diagnostic/Feasibility Study for Clear Lake, California. Prepared for Lake County Flood Control and Water Conservation District, California State Water Resources Control Board and United States Environmental Protection Agency.

Richerson, P.J., T.H. Suchanek, R.A. Zierenberg, D.A. Osleger, A.C. Heyvaert, D.G. Slotton, C.A. Eagles-Smith, and C.E. Vaughn. 2008. "Anthropogenic stressors and changes in the Clear Lake ecosystem as recorded in sediment cores". *Ecological Applications* Vol. 18 No. 8: 257-283.

Rideout, W.L. 1899. A Fish Jam on Kelsey Creek. *Overland Monthly and Out West Magazine*. Vol. 34, Issue:202, Oct 1899. In Making of America Journal Articles Website. http://quod.lib.umich.edu/cgi/t/text-idx?c=moajrnl&idno=ahj147.2-34.201 (Accessed 01.24.08)

Roberts, R.C. 1984. "The Transitional Nature of Northwestern California Riparian Systems" in R.E. Warner and K.M. Hendrix (Editors) *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley: University of California Press. http://content.cdlib.org/xtf/view?docId=ft1c6003wp&chunk.id=d0e563&toc.depth=1&toc.id=d0e563&brand=eschol (Accessed 03.31.04)

Robichaud, P.R. 2000. "Forest Fire Effects on Hillslope Erosion: What We Know". *Watershed Management Council Newsletter*. Vol. 9. No. 1. http://www.watershed.org/wmc/modules.php?op=modload&name=PostWrap&file=index&page=/aboutwmc.html (Accessed 03.11.08)

Ryan, S. 2004. Cultural Resources List. A List of Items In and Around Clear Lake that are Commonly Used or Consumed by the Big Valley Band of Pomo Indians. February 24, 2004.

SAF (Society of American Foresters). 2004. "Preparing a Community Wildfire Protection Plan, A Handbook for Wildland-Urban Interface Communities". http://www.safnet.org/policyandpress/cwpphandbook.pdf (Accessed 05.12.08)

SMFE (Soil Mechanics and Foundation Engineers, Inc.) 1964. Kelsey Creek Dam Project Geological and Soil Engineering Feasibility Report. Prepared for Lake County Flood Control and Water Conservation District.

SMFE (Soil Mechanics and Foundation Engineers, Inc.) 1967. Big Valley Ground-water Recharge Investigation. Prepared for Lake County Flood Control and Water Conservation District.

SLSII (Sustainable Land Stewardship Institute International). 1999. Webpage on Bioassessment in California. http://www.slsii.org/biocal.htm (Accessed 02.05.08)

SVWQC (Sacramento Valley Water Quality Coalition) 2006. Section 5.0 Monitoring Phases and Parameters.

SWRCB (State Water Resources Control Board). 2008. "401 Water Quality Certification Discharges of Dredged or Fill Materials Under the Clean Water Act Section 401". http://www.waterboards.ca.gov/water_issues/programs/cwa401/docs/questions_answers.pdf (Accessed 01.22.09)

SWRCB and LCFCWCD (State Water Resources Control Board and Lake County Flood Control and Water Conservation District) 2005. Proposition 13 Watershed Protection Grant Program, Grant Agreement No. 03-237-555-0.

Simoons, F.J. 1952. "The Settlement of the Clear Lake Upland of California. Masters Thesis, University of California, Berkeley.

Sims, J.D., M.J.Rymer and J.A. Perkins. 1988. Quaternary Deposits Beneath Clear Lake, California; Physical Stratigraphy, Age, and Paleogeographic Implications. Geological Society of America Special Paper 214.

Smithsonian Institution. 2004. Global Volcanism Program website. Found in http://vulcan.wr.usgs.gov/Volcanoes/California/ClearLake/description_clear_lake.html (Accessed 04.16.08)

State of California, Department of Finance. 2007. Population Projections for California and Its Counties 2000-2050, by Age, Gender and Race/Ethnicity, Sacramento, California, July 2007. http://www.dof.ca.gov/html/DEMOGRAP/ReportsPapers/Projections/P3/P3.php (Accessed 05.17.08)

Stuart, J.D. and S.L. Stephens. 2006. 'North Coast Bioregion' in N.G. Sugihara, J.W. Van Wagtendonk, J. Fites-Kaufman, K.E. Shaffer and A.E. Thode (Editors) *Fire in California's Ecosystems*. University of California Press, Berkeley.

Tudor Engineering Co. 1973. Kelsey Creek Water Supply Project Feasibility and Loan Application Report Small Reclamation Project Act-P.L. 984 Draft- November 1973. Prepared for Lake County Flood Control and Water Conservation District.

Tudor Engineering Co. 1982. Kelsey Creek Water Supply Project 1981 Update. Prepared for Lake County Flood Control and Water Conservation District.

UCANR (University of California Agriculture and Natural Resources). 2006. Frequently asked questions related to sudden oak death. News and information outreach. Septermber 10, 2002. Updated May 2006. http://news.ucanr.org/newsstorymain.cfm?story=450 (Accessed 03.25.08)

UCIPM (University of California Integrated Pest Management Program). 2007. Light Brown Apple Moth in California: Quarantine, Management, and Potential Impacts. http://www.ipm.ucdavis.edu/EXOTIC/lightbrownapplemoth.html (Accessed 05.27.08).

USDA (United States Department of Agriculture). 2008. Laws and Regulations, USDA National Agricultural Library, National Invasive Species Information Center http://www.invasivespeciesinfo.gov/laws/execorder.shtml#sec1 (Accessed 06.01.08)

USDAFS (United States Department of Agriculture Forest Service). 2005. Wildland Waters. Summer 2005 issue.

USDAFS (United States Department of Agriculture Forest Service). 1999. Watershed Analysis Report Upper Lake Watershed.

USFWS (United States Fish and Wildlife Service). 2008. Invasive species. Laws and Regulations. http://www.fws.gov/invasives/laws.html (Accessed 06.01.08)

USDA NRCS (United States Department of Agriculture, Natural Resources Conservation Service). 1998. Stream Corridor Restoration Principles, Processes and Practices. 10/98 Published Version, Revised 8/2001. http://nrcs.usda.gov/technical/stream_restoration/newtofc.htm (Accessed 01.03.08)

USDASCS (United States Department of Agriculture Soil Conservation Service). 1989. Soil Survey of Lake County, California.

USGS (United States Geological Survey). 2008. Zebra and Quagga mussel page. http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/ (Accessed 05.30.08)

USSARTF (United States Search and Rescue Task Force). 2008. Landslides. http://www.ussartf.org/landslides.htm (Accessed 05.19.08)

United States. 1999. Federal Register, Volume 64, Number 25, Monday, February 8, 1999, Presidential Documents.

Water Encyclopedia. 2008. Groundwater. http://www.waterencyclopedia.com/Ge-Hy/Groundwater.html (Accessed 01.03.08)

Week, L.E. 1982. Habitat Selectivity of Littoral Zone Fishes in Clear Lake, California. Inland Fisheries Administrative Report No. 82-7. State of California The Resources Agency Department of Fish and Game.

Wikipedia. 2007. Chaparral. http://en.wikipedia.org/wiki/Chaparral (Accessed 02.12.08)

Wikipedia. 2008. Invasive Species. http://en.wikipedia.org/wiki/Invasive_species (Accessed 05.27.08)

Williams, D.F. and K.S. Kilburn. 1984. "Sensitive, Threatened, and Endangered Mammals of Riparian and Other Wetland Communities In California" in R.E. Warner and K.M. Hendrix (Editors) *California Riparian Systems: Ecology, Conservation, and Productive Management.* Berkeley: University of California Press. http://content.cdlib.org/xtf/view?docId=ft1c6003wp&chunk.id=d0e563&toc.depth=1&toc.id=d0e563&brand=eschol (Accessed 03.31.04)

Williams, G.W. 2003. References on the American Indian Use of Fire in Ecosystems. Compiled by Gerald W. Williams, Ph.D. Historical Analyst USDA Forest Service, Washington D.C. June 12, 2003. http://www.blm.gov/heritage/docum/Fire/Bibliography%20-%20Indian%20Use%20of%20Fire.pdf (Accessed 04.30.08)

Windrem, P.F. 2008. Chi Council for the Clear Lake Hitch Interim Report on Activities. January 1, 2008. http://www.lakelive.org/chicouncil/2008report.htm (Accessed 02.12.08)

WLRCD and UPCS (West Lake Resource Conservation District and Upper Putah Creek Stewardship). 2004. Lake County Stream Team Q.A.P.P. Upper Cache Creek & Upper Putah Creek.

WRCC (Western Regional Climate Center). 2008. Hobergs, California Climate Summary. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca4010 (Accessed 01.15.2008)

Zack, S. 2002. The Oak Woodland Bird Conservation Plan: A Strategy for Protecting and Managing Oak Woodland Habitats and Associated Birds in California. Version 2.0 A Project of California Partners in Flight and Point Reyes Bird Observatory. http://www.prbo.org/calpif/htmldocs/oaks.html (Accessed 03.24.08)

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